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AGENCY FOR INTERNATIONAL DEVELOPMENT

EVALUATION OF THE HYDROELECTRIC DEVELOPMENT PROGRAM

OF

KYRGYZSTAN

FINAL REPORT

Prepared by

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EVALUATION OF THE HYDROELECTRIC DEVELOPMENT PROGRAM OF KYRGYZSTAN

EXECUTIVE SUMMARY

Introduction

Hydroelectric energy potential is the most important indigenous energy resource in Kyrgyzstan. Over 80 percent of the country's installed generating capacity, and a similar percentage of total annual electric energy generation, derives from hydroelectric resources. Furthermore, developed hydroelectric capacity represents less than 11 percent of the total development potential.

The exploitation of this important resource has therefore been a high priority of the governing authorities since the mid 1960's, when a program was commenced to develop hydropower facilities in the Naryn river basin which covers a substantial portion of the country's geographic area. The first phase of this program included the development of the Lower Naryn river with the construction of the large Toktogul reservoir and four downstream projects. This phase is now being finalized with the completion of the Tashkumir and Shamaldisai projects. These projects have an ultimate installed capacity of 2,770 MW and an average annual energy generation of 10,000 GWh. However, their operation is driven by irrigation releases in the summer, with the result that summer energy production exceeds Kyrgyzstan's internal demand. On the other hand, the demand for electricity is at its highest in the winter, and a second phase of development -- planned before the breakup of the Soviet Union -- was to develop sites upstream of the Lower Naryn projects to meet this demand, starting with the Kambarata projects. However, the transition of the Central Asian republics to sovereignty and market-based economies has necessitated a postponement of this development phase, pending an updated assessment of electricity demand, costs and benefits, and financing potential.

The present studies are thus a part of the Kyrgyzstan State Energy Company's program to determine and pursue the optimal development of the hydroelectric resources of Kyrgyzstan. This over-riding objective is accomplished through performance of the following major tasks:

- *Review of the electric power market demand,*
- *Review of the most promising upstream sites: Kambarata, Kirov and Upper Naryn projects,*
- *Development of new construction cost estimates,*
- *Performance of reservoir operation studies and economic evaluations, and*
- *Making recommendations bearing on the operation and expansion of hydroelectric facilities.*

Funds for this study were provided by the United States Agency for International Development (USAID). Throughout the study, excellent technical coordination and cooperation was provided by the personnel of the Kyrgyzstan State Energy Company (KSEC) and the Tashkent Hydro Design Institute (THDI).

Electric Power Sector

The Kyrgyzstan State Energy Company (KSEC) is responsible for electrical power generation in Kyrgyzstan. It is a state-owned enterprise under the authority of the Ministry of Energy. Plans are underway for the KSEC to become a joint-stock company. It currently operates 20 generating stations with a total installed capacity of 3,414 MW, of which 2,740 MW or 80 percent are from hydropower facilities, and 674 MW are from two thermal powerplants which are also used for district heating in the cities of Bishkek and Osh.

The hydropower facilities of the Naryn river are concentrated in the lower reaches. Figure 1 shows a profile of the Lower Naryn with the location and installed capacities of the existing hydroelectric stations and proposed Kambarata projects.

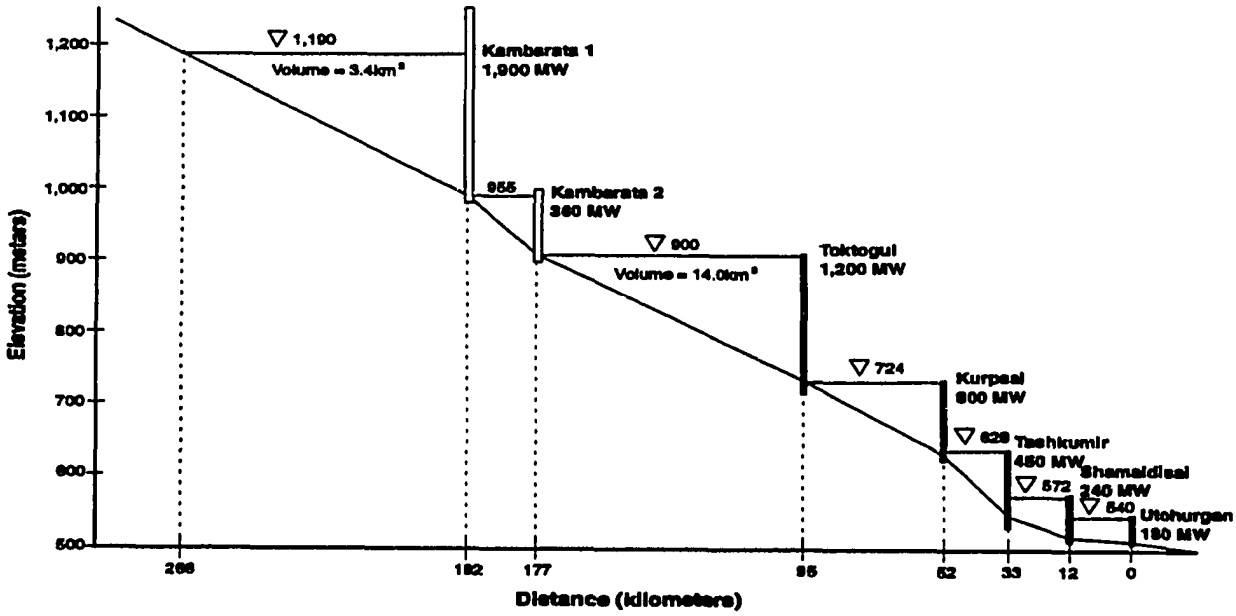

Figure 1: Existing and Proposed Hydropower Projects on the Naryn River

In 1992, Kyrgyzstan's total electricity production was 11,793 Gwh, 78 percent of which was generated by hydroelectric facilities. The peak demand is in December or January, while summer demand is about 60 percent of the winter peak. In 1992, the peak power demand was about 1,850 MW. Figure 2 shows the 1992 monthly distribution of energy consumption.

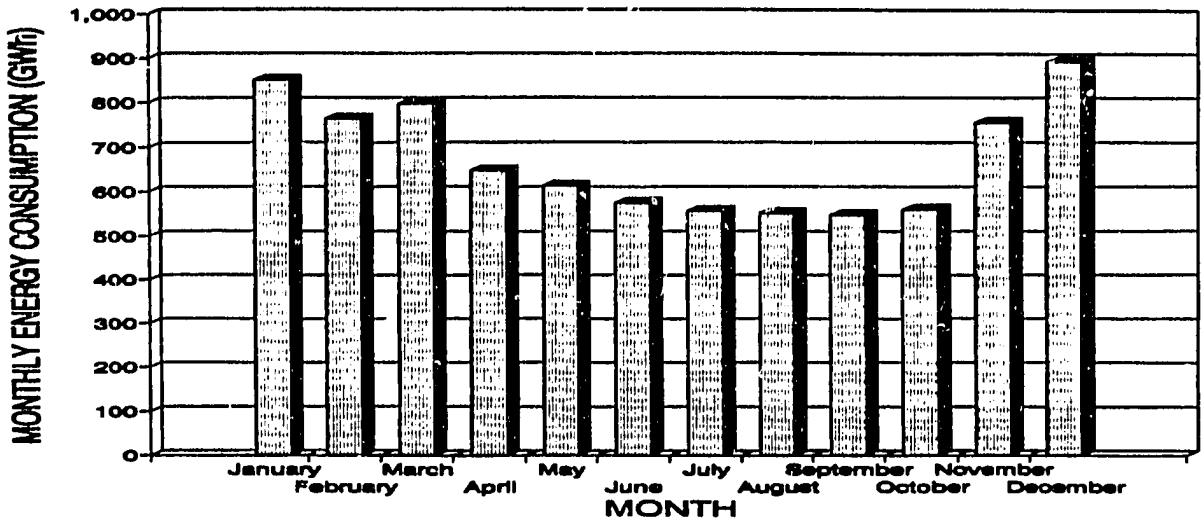

Figure 2: 1992 Monthly Distribution of Energy Consumption

Historically, reservoir release for hydropower generation has been dictated by irrigation demand which is highest in the summer, and excess hydroelectric energy is exported to other Central Asian countries via a 500-kV transmission grid that interconnects the countries of Turkmenistan, Uzbekistan, Tadjikistan, and Southern Kazakhstan as shown below on Figure 3.

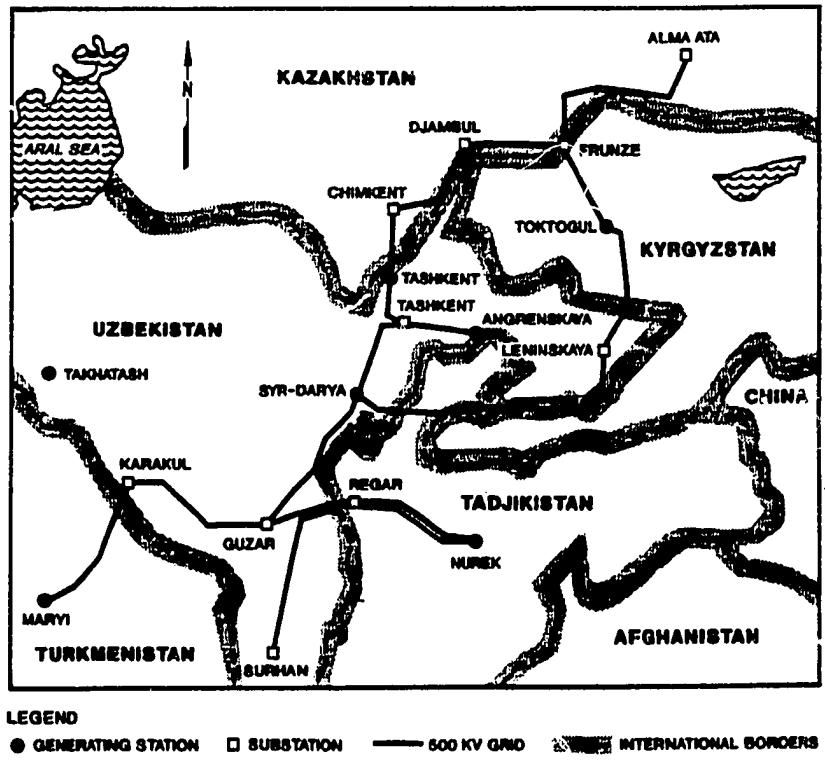

Figure 3: 500-kV Transmission System of Central Asia

Net annual exports from Kyrgyzstan averaged about 5,000 GWh during the period 1988-1991, but have been reduced during the current period of political and economic transition. In 1992, exports were only 2,176 GWh.

Electric Power Market Demand

The evolving economic and political realities facing the former Soviet republics have affected current energy demand and future economic growth. In the electrical sector, recent declines in industrial consumption have been more than offset by a major increase in residential demand. Fuel prices (coal, gas or oil) have greatly increased over the past two years to approach world free-market price levels, while the price of electricity has remained very low. This has resulted in a shift towards electric heating appliances and a 75 percent increase in residential demand between 1990 and 1992. This trend has continued over the first six months of 1993.

To reflect the current uncertainties of the short- and long-term economic forecasts of Kyrgyzstan and of the power exchanges between the various republics of Central Asia and the surrounding countries, three scenarios were developed. These scenarios -- designated High Growth, Moderate Growth, and Low Growth -- were developed for the period 1993-2010 to show the range of potential demand. The energy forecast developed by the Republic of Kyrgyzstan was assumed as a "High Growth" scenario. The two other scenarios were based on revised assumptions underlying the High Growth scenario, involving duration of economic contraction and strength of eventual recovery, various forecasting methodologies, and historical trends; and discussions with representatives of the electric power sectors of Kyrgyzstan, Kazakhstan and Uzbekistan. The internal demand of Kyrgyzstan was analyzed separately from subsequent projections of the export market. Historical data and projections for the energy consumption of Kyrgyzstan are shown graphically in Figure 4.

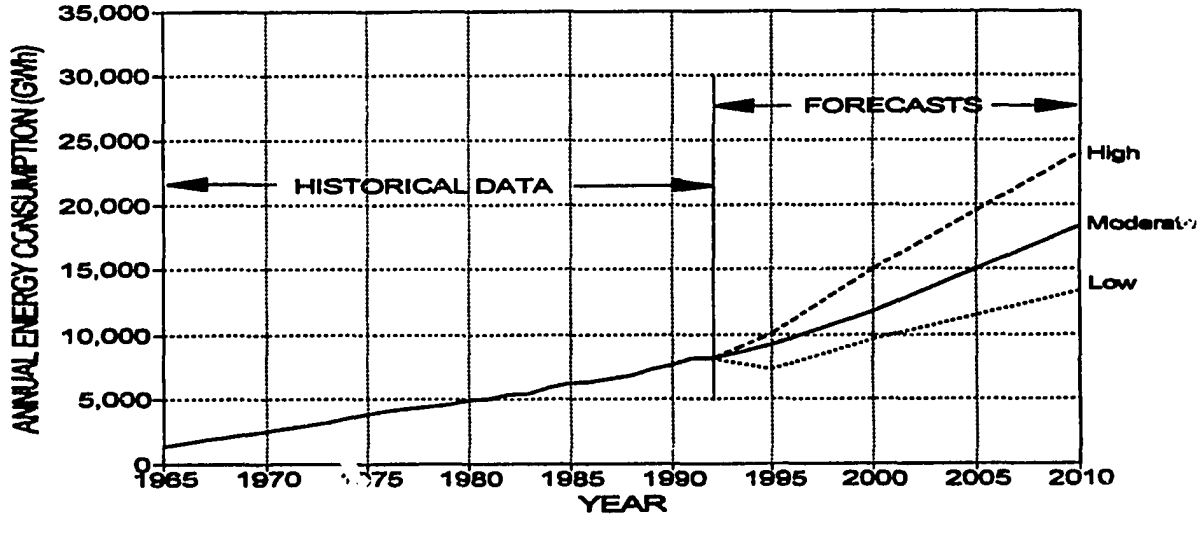

Figure 4: Historical and Projected Energy Consumption of Kyrgyzstan

Under the High Growth or official scenario, the demand would grow at an average annual growth rate of 8.0 percent for the period 1995-2000 and 4.8 percent for the period 2000-2010. Under the Moderate Growth scenario, the demand is expected to increase from 8,112 GWh in 1992 to 11,750 GWh in 2000 and to 18,350 GWh in 2010. This would be represented by an average annual growth rate of 4.7 percent for the period 1992-2000, and 4.6 percent for the period 2000-2010. For the Low Growth scenario, annual demand would decline by 9.8 percent until 1995 due to declining industrial consumption and slower residential demand growth, after which time an average growth rate of 4.1 percent would be assumed.

In addition to generating electricity to meet internal consumption, Kyrgyzstan has been a net exporter of electricity since 1978 involving seasonal exchange. Between 1988 and 1991, net exports averaged about 5,000 GWh per year, and have been reduced since then as a ramification of the new political and economic realities of the region.

Currently there are no long-term power sales agreements between the republics of Central Asia. However, assumptions of future exports were included in the official or High Growth scenario, with alternative export forecasts developed for the other two scenarios. There is a need, however, to clearly define the power market of Central Asia and the export potential from Kyrgyzstan as important considerations which are beyond the scope of this study.

For this study, net exports are expected to vary between 1,500 and 2,000 GWh until year 2000 and regain their 1988-91 level thereafter. Net exports are expected to vary between 4,500 GWh (Low Scenario) and 6,500 GWh (Moderate and High) in the year 2010. Historical data and projections for the internal demand of Kyrgyzstan combined with net exports are shown graphically in Figure 5.

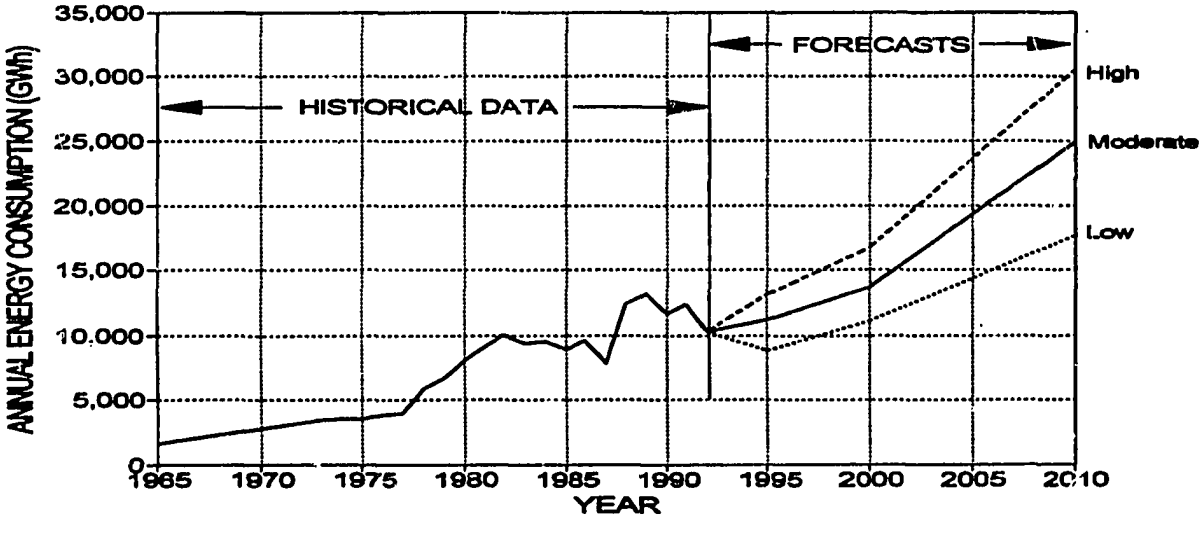

Figure 5: Historical and Projected Demand Including Net Exports

Kambarata, Kirov and Upper Naryn Hydroelectric Projects

Of the 26,000-MW hydroelectric potential of Kyrgyzstan only 2,740 MW have been developed to date, primarily on the lower Naryn river. The development of the Naryn river and its tributaries has been planned by the KSEC and the THDI. Preliminary, feasibility, and/or pre-design studies have been performed for many sites. For this study, KSEC selected to review the following sites for their economic attractiveness, stage of development (Kambarata), power addition to existing facilities (Kirov), and service for an isolated regional area and growing export market (Upper Naryn).[1] They are

- *Kambarata 1 and 2 projects - totaling 1,900 MW and 360 MW, respectively, and located in the middle part of the Naryn river between the Togoztural basin in the east and the Ketmentub basin in the west, just upstream of the reservoir formed by the existing Toktogul hydroelectric project.*

- *Kirov project - totaling 21 MW and located at the site of an existing dam and irrigation water storage reservoir on the Talas River in northwestern Kyrgyzstan.*

- *Upper Naryn projects - comprised of eight sites in the Upper Naryn basin and totaling 529.5 MW.*

Kambarata Projects

Kambarata 1. As proposed by THDI, the Kambarata 1 project consists of a 275-m-high dam built by controlled blasting, two combined power/spillway tunnels, four penstocks, a 4-unit powerhouse and an outdoor switchyard. The reservoir would have a live storage of about 3,430 million cubic meters and provide seasonal storage. The installed capacity of the plant will be 1,900 MW (maximum net head of 185 m with a total discharge of 1,150 m^3/s). The average energy production is 5,088 GWh/yr. Design head is 166.5 m and design unit discharge amounts to 270 m^3/s. A conventional dam alternative, consisting of a concrete double-curvature arch dam and 1,700 MW of installed capacity, which had also been analyzed by THDI, was reviewed for this study as well. New cost estimates were developed for both dams. The total construction cost is estimated to vary between $1.67 billion for the blast dam alternative and $1.85 billion for the arch dam alternative (March 1993 price level).

Kambarata 2. The Kambarata 2 Project is located just downstream of the Kambarata 1 Project and is about 30 percent complete. Although the construction started before Kambarata 1 was initiated, important project features were designed and built based on the

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[1] A number of additional sites, while possibly attractive, are located farther away from load centers or 500-kV transmission lines and were not subject to this evaluation. Other small hydro and mini-hydro projects were developed in the 1920's and 1930's and are presently abandoned; their rehabilitation may also be economically attractive, but again, were not part of this evaluation.

assumption that the Kambarata 1 dam would be in place by the time the downstream development was completed, or at least very soon after completion. The proposed project consists of a 62-m-high blast dam, a three-bay power intake and three parallel power tunnels, a spillway tunnel, a three-unit surface powerhouse and outdoor switchyard. The installed capacity of the plant will be 360 MW. The average energy production is estimated at 1,116 GWh. The design net head of the installation is 47.5 m and the unit design discharge amounts to 280 m^3/s. A conventional fill dam was also reviewed. The total construction cost to complete the project is estimated to vary from between $261 million (blast dam) and $281 million (fill dam).

An initial staged development was investigated that comprised only a two-unit installation instead of three units. Average annual energy generation would only be reduced by about 4 percent. This would, however, result in an initial investment reduction of about $30 million.

Kirov Project

The existing water storage reservoir of the proposed Kirov Hydroelectric Project has been operated since 1975 for seasonal regulation of water which is used from April to September for downstream irrigation. The reservoir provides seasonal storage for about 105,000 hectares (ha) which include 20,000 ha in Kyrgyzstan and 85,000 ha in Kazakhstan. The hydroelectric project would use the irrigation discharges to produce electric energy. Therefore, under current operating conditions, it would produce small amount of energy in the peak demand months in the winter, and large amount of energy in the summer. The project proposed by THDI consists of a power intake at the existing dam, a power tunnel through the right bank of the river, a surface penstock with a manifold trifurcation leading to a 3-unit powerhouse, a tailrace canal, and an outdoor switchyard. The installed capacity of the plant will be 21 MW (net design head of 41 m, 3-unit discharge of 59 m^3/s). The average energy production is estimated at 69.7 Gwh/yr. Total construction cost for the Kirov project is estimated at $ 19.4 million.

Upper Naryn Projects

The Upper Naryn hydroelectric potential was investigated by THDI in the late 1980's. Eight sites were inventoried (reconnaissance study level). One of them, the Naryn 1 Hydroelectric Plant, was developed at the feasibility level (Technical and Economic Analyses) in 1992. Table 1 presents the main characteristics of the eight powerplants, as defined by THDI.

Table 1

UPPER NARYN HYDROELECTRIC PROJECTS

Project Name	Project Type	Design Net Head (m)	Design Discharge (m^3/s)	Installed Capacity (MW)	Dependable Capacity (MW)	Annual Energy Production (GWh/yr)
Oruktam 1	RES	97	70	60	40	254
Oruktam 2	DIV	112	50	48	43	259
Echinaryn	DIV	22	50	9	8	50
Dzhanykel	RES	141	109	130	48	470
Akbulunsk	ROR	74	157	100	24	372
Naryn 1	DIV	45	157	62	14	227
Naryn 2	DIV	43	160	60	15	235
Naryn 3	DIV	50	160	60	17	254
TOTAL	n/a	n/a	n/a	529	n/a	2,121

Notations : RES = Reservoir storage project
ROR = Run of river
DIV = Diversion project (canal or tunnel)

Construction Cost Estimates

Extensive discussions were held with KSEC, THDI, and the Naryn Hydro Energy Construction Company (NHECC) which has been building all the Lower Naryn hydropower projects. The latest cost estimates prepared by THDI and prices available from the Ministry of Economics, which all reflect a March 1993 price level, were reviewed. These estimates and prices were converted into US dollars by using an exchange rate of 800 roubles per dollar. This conversion resulted in unit prices (US dollar per installed kilowatt) considerably below international price levels. New cost estimates were then developed to reflect current and future market conditions and international bidding.

New estimates were developed for labor costs, materials costs and construction equipment rates. Labor is expected to be of national origin. An experienced construction work force is available from the NHECC for future projects. The origin of materials and equipment was considered, either from the national market or imported from Russia or other countries. In addition, an analysis of construction costs of hydropower projects in India, Pakistan and

China was performed to serve as an additional basis for cost estimates in Kyrgyzstan. Current prices were modified to reflect rapid changes in the price structure of imported fuels, material, and equipment. Construction cost estimates were derived based on quantities developed by the THDI and Harza. The costs are summarized in Table 2, and they reflect a March 1993 price level.

Table 2

CONSTRUCTION COST ESTIMATES

Project Name	Installed Capacity (MW)	Average Annual Energy (GWh)	Construction Cost Total ($x10^6)	Construction Cost Unit Cost ($/kW)
Kambarata 1				
Controlled Blast Dam	1,900	5,088	1,675	882
Arch Dam	1,700	4,611	1,850	1,088
Kambarata 2				
2-unit	240	1,072	231	961
3-unit	360	1,116	261	724
Kirov	21	70	19	925
Oruktam 1	60	254	180	3,000
Oruktam 2	48	259	180	3,750
Echinaryn	10	50	37	3,750
Dzhanykel	130	470	176	1,358
Akbulunsk	100	372	135	1,350
Naryn 1	62	227	97	1,562
Naryn 2	60	235	100	1,667
Naryn 3	60	254	115	1,917

Reservoir Operation Studies

The primary purpose and the current practice of the Toktogul reservoir has been to provide multi-year and seasonal storage for irrigation demand in Uzbekistan and Kazakhstan. Water is stored behind the Toktogul reservoir for summer releases to meet this demand. The projects downstream of Toktogul do not have seasonal storage and are used for daily peaking and regulation. Power and energy is generated as the by-product of irrigation releases. As a result, electricity generation in the summer months is in excess of the internal demand of Kyrgyzstan. Within the former Soviet Union, this excess was transmitted to the other republics of Central Asia through the 500-kV transmission network (see Figure 3). In winter, when water was conserved for the summer irrigation requirements, power would flow back from the other Central Asian republics into Kyrgyzstan to meet the winter load of Kyrgyzstan. A regional balance and optimization of water for power and irrigation was achieved.

Reservoir operation studies performed by THDI, based on these past irrigation priorities, were therefore reviewed, and then a series of alternative reservoir operation studies were performed to evaluate the operation of these projects as primarily power projects with a constant minimum release of only 100 m^3/s for downstream requirements. This was done to evaluate the output of existing and future projects if they were to meet the electrical power demand of Kyrgyzstan as a first priority. Figure 6 graphically shows the results of monthly dependable energy generation from the existing projects and the addition of Kambarata 1 and 2 under both modes of operation: irrigation and power scenarios. Under the power scenario, energy output from the hydro facilities would closely follow the monthly fluctuations of the internal demand of Kyrgyzstan (as shown on Figure 2 for year 1992) and would meet that demand without any power shortages during the winter months.

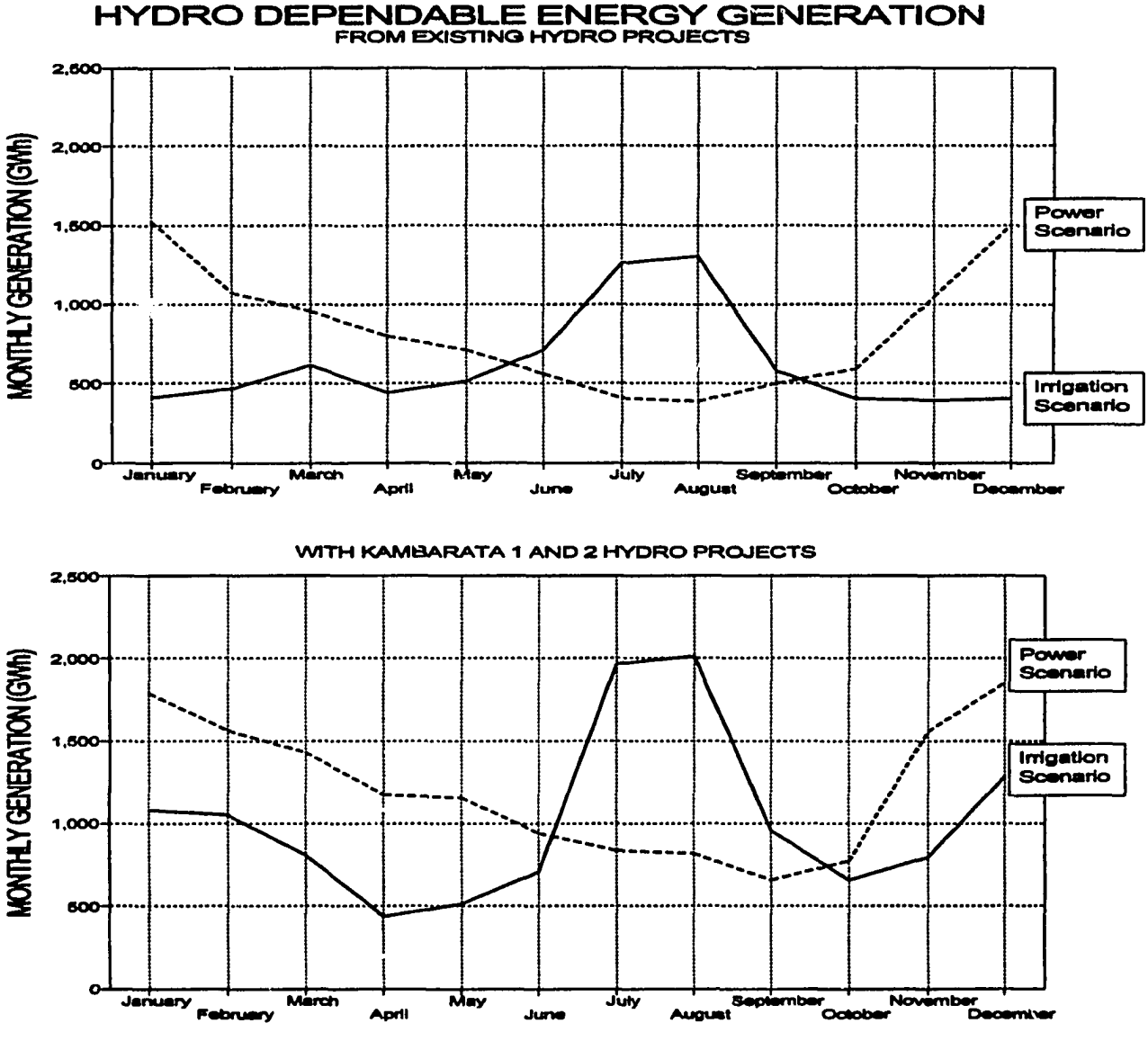

Figure 6: Monthly Hydropower Energy Generation

Economic Evaluation

An economic analysis was conducted to evaluate the economic feasibility of the proposed hydroelectric projects by comparing them to the most likely thermal alternatives: coal-fired, combined cycle gas turbine, or gas turbine powerplants depending on the size and operating mode of the hydropcwer project. Table 3 presents input data specific to the thermal alternatives. Two sets of assumptions are presented to reflect the differences in size and location the hydropower projects. These assumptions are based on international construction costs of thermal plants and fuel prices. Similar assumptions were made for the development of the hydro construction costs. These construction and operating costs are also representative of thermal costs of new facilities in Uzbekistan and Kazakhstan. Projects economically attractive for Kyrgyzstan would show a similar economic rate of return for Uzbekistan and Kazakhstan. A 12 percent real discount rate and no escalation or inflation were used in the economic analysis.

Table 3

ECONOMIC ANALYSIS - INPUT DATA FOR THERMAL GENERATION

	Large Projects		Small Projects	
	Coal-Fired	CCGT	Coal-Fired	GT
Construction Cost ($/kW)	1,300	750	1,600	500
Fixed O&M Cost ($/kW/year)	25	15	30	25
Variable O&M Cost ($/MWh)	2.5	3.5	3.0	5.0
Type of Fuel	Coal	Gas	Coal	Gas
Price of Fuel ($/MBtu)	2.0	4.0	2.5	5.0
Energy Value ($/MWh)	20	30	25	60
Construction Period	4	2	4	1

Table 4 summarizes the results of the economic analysis. The Kambarata 2 project was analyzed under two modes of development. The first mode of development assumes an initial phase with two units and an installed capacity of 240 MW due to the potential postponement of the upstream Kambarata 1 storage project. The second mode of development assumes that the Kambarata 1 project will be built shortly thereafter and the Kambarata 2 project has three units with an installed capacity of 360 MW. The Kambarata 2 project shows an attractive benefit-cost (B/C) ratio under both alternatives: 1.26 and 1.68, respectively, using a 12 percent discount rate. The corresponding equalizing discount rates (rate of return) are 16.3 and 26.2 percent, respectively.

The Kambarata 1 project is also economically attractive with a B/C ratio of 1.25 and an equalizing discount rate of 15.9 percent for the controlled blast dam alternative, and a B/C ratio of 1.09 and an equalizing discount rate of 13.4 percent for the arch dam alternative. The Kambarata 1 project would also provide additional firm and secondary power and

energy benefits to the Kambarata 2 project, which would further increase the economic attractiveness of the project.

The Kirov project is marginally attractive with a B/C ratio of 0.96 and an equalizing discount rate of 11.3 percent. The Upper Naryn projects have B/C ratios varying between 0.74 and 1.20. Construction costs of these projects should be refined and a more detailed analysis of alternative thermal generation costs to provide electricity in the areas surrounding these hydropower projects should be performed.

Table 4

RESULTS OF THE ECONOMIC ANALYSIS

Project Name	Benefit-Cost Ratio	Equalizing Discount Rate (%)
Kambarata 2		
2-unit	1.26	16.3
3-unit	1.68	26.2
Kambarata 1		
Controlled Blast Dam	1.25	15.9
Arch Dam	1.09	13.4
Kirov	0.96	11.3
Oruktam 1	0.75	7.3
Oruktam 2	0.80	8.1
Echinaryn	0.74	7.1
Dzhanykel	1.11	14.0
Akbulunsk	1.20	15.2
Naryn 1	1.03	12.5
Naryn 2	1.04	12.5
Naryn 3	0.98	11.7

Hydro Expansion Program

Figure 7 shows the demand and supply under the Moderate- and Low-growth scenarios with and without net exports. In addition to the existing thermal and hydro facilities, only the Kambarata 1 and 2 projects have been added. For the existing thermal facilities, it was assumed that their generation output would be associated with district heating requirements and would not increase over time. The corresponding annual thermal energy generation is expected to be about 3,950 GWh. Since hydropower generation varies depending upon the amount of runoff available, both the firm (or dependable) and average hydro energy generation are presented in Figure 7. It was assumed that the excess hydro energy generated during the summer would be exported to surrounding republics and compensated

by thermal imports in the winter. Hydro energy presented in Figure 7 corresponds to total average annual energy that can be produced by the projects.

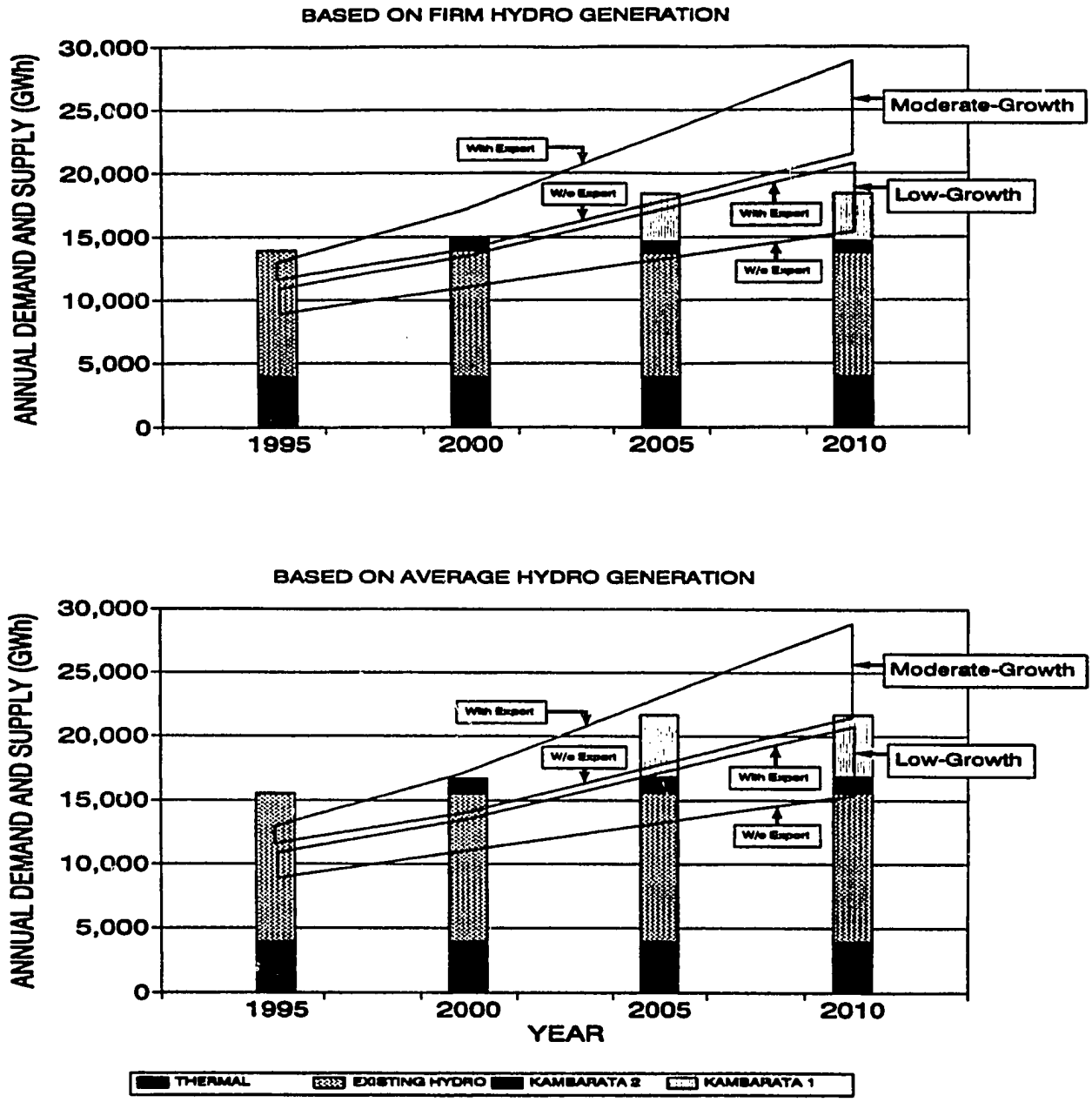

Figure 7: Demand and Supply

Perusal of Figure 7 reveals that, under the Moderate-growth scenario, additional generation would be required by the end of the 1990's if Kyrgyzstan wants to continue meeting their

export market and even their own internal demand under drought conditions. Then, depending on the assumptions made on future demand within Kyrgyzstan and the amount of energy that can be exported from Kyrgyzstan, the Kambarata 1 project would need to be in operation sometime during the next decade.

Conclusion

Future electricity demand outlook, trade (exports) incentives, and operational benefits relative to costs indicate that the construction of the Kambarata 1 and 2 hydropower projects should be pursued as a top priority of the Government of Kyrgyzstan. The Kambarata 2 project is already under construction and major works such as power tunnels are well underway. About 30 percent of the construction is complete (see Figure 8 which shows a photograph of the power tunnel outlets and powerhouse foundation excavation), but a current lack of funding has brought construction activities to a halt. The European Bank for Reconstruction and Development (EBRD) has performed a parallel study on this project and is already looking into financing options to complete the Kambarata 2 project. At the same time, preparation of technical and financial documents required for financing the implementation of the Kambarata 1 project should continue.

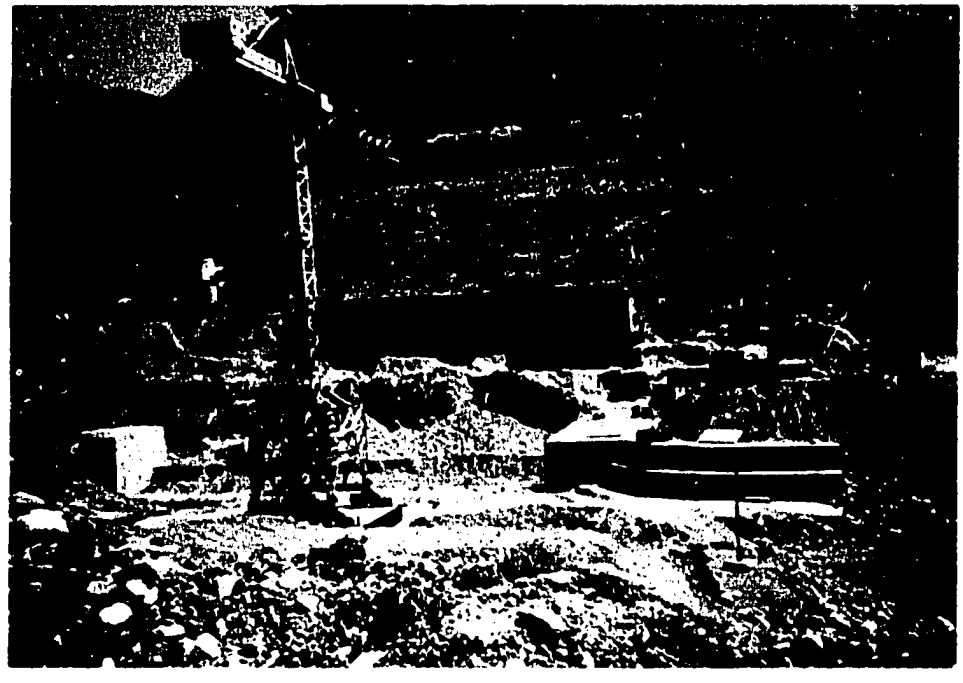

Figure 8: Construction Site of Kambarata 2 Project

The export of hydro electricity from Kyrgyzstan to Uzbekistan and Kazakhstan should also be considered into the overall energy balance of payments for Kyrgyzstan. Kyrgyzstan has severe energy deficits and imports coal, oil and gas from both Uzbekistan and Kazakhstan.

At the same time, these two countries have vested interests in the operation of the Toktogul reservoir to maintain adequate storage for summer irrigation releases, specially during drought years. Development of the Kambarata projects would provide a major increase of hydropower generation in the winter months while maintaining water storage in the Toktogul reservoir for irrigation purposes. A strong cooperation between these countries and international lending agencies would make the implementation of the Kambarata projects very attractive, both for power and irrigation benefits.

Recommendations for Further Action

Further activities are recommended:

Kambarata Projects

(1) The Government of Kyrgyzstan should declare that the completion of the Kambarata 2 project is a top funding priority.

(2) The design of the Kambarata 2 project should be refined for an initial 240 MW development with provision to add a third 120 MW unit.

(3) All necessary technical and financing-related information should be compiled for the preparation of tender documents for civil works and equipment supply and Banks' approval of construction financing for the Kambarata 2 project.

(4) The configuration of the dam for the Kambarata 1 project should be finalized through a comparison of the proposed controlled blasting techniques to a more conventional design such as concrete arch dam. Staging development and ways to reduce initial investment should also be considered.

(5) Contacts should be made with neighboring countries to discuss their potential participation in the development of the Kambarata projects.

General Hydropower-Sector Activities

(1) Existing contractual agreements between the Central Asian republics regarding the use and operation of the Toktogul reservoir and other uses of the Naryn and Syrdaya rivers for irrigation and power should be reviewed. Long-term operating criteria for the Toktogul project should be developed that are acceptable to all parties, and benefits and costs should be established.

(2) The electricity export potential to the neighboring republics and other countries nearby should be delineated, and legal and contractual documents related to short-

and long-term power exchanges between Kyrgyzstan and the various Central Asian republics should be negotiated.

(3) Sources of international and local financing should be secured, and an appropriate legal and institutional structure (e.g., a joint-stock corporation) should be established to develop hydroelectric projects.

(4) The need for rehabilitation/upgrade and expansion of the transmission/distribution network of Kyrgyzstan to meet increased level of electrification, residential electric heating demand, and export should be planned. Tender documents for equipment supply should be prepared.

(5) The need for improvements in telecommunications and controls between the dispatch centers of Kyrgyzstan and other Central Asia republics should be assessed.

FOREWORD

Authorization

This study was performed in accordance with the terms of the memorandum of understanding signed between Kyrgyzstan State Energy Company and Harza Engineering Company. Funds for the study were provided by the United States Agency for International Development (USAID), indefinite quantity contract PCE-0001-I-00-2053-00.

Background

The present studies are a part of the Kyrgyzstan State Energy Company's program to encourage development of hydroelectric resources.

In July 1992, USAID sponsored the United States Energy Industry Tour, which was coordinated through the United States Energy Association (USEA). A delegation of six senior energy officials from the Kyrgyzstan State Energy Company (KSEC) met with a number of USEA member organizations in several states including Harza in Chicago, Illinois.

Discussions between Harza and Kyrgyzstan officials led to the signing of a Letter of Intent on Cooperation for preparation of an investigation report of several proposed hydroelectric developments, July 14, 1992.

In August, a delegation from USAID visited Kyrgyzstan, at which time they agreed to provide assistance for the development of hydroelectric power resources. A document entitled "Proposition of Collaboration" was prepared by KSEC and a Memorandum of Energy Sector Discussions was prepared (August 21, 1992).

Harza's representative, Mr. Carl M. Brown, visited the Kyrgyzstan State Energy Company from November 2 to November 5, 1992 in order to review existing data and to develop the scope of services for the existing study. A contract was then negotiated with USAID and signed on April 15, 1993.

Objectives and Scope

The main objectives of this study are: 1) to evaluate the technical and economic basis for further development of the hydroelectric industry in the Republic of Kyrgyzstan as a means of attracting national or private capital; 2) to transfer technology from the U.S.A. to Kyrgyzstan through active participation of KSEC in most phases of the scope of services; and 3) to provide recommendations to the government of Kyrgyzstan for future actions.

The study was accomplished through the completion of eight major tasks:

1. Data Collection;
2. Power Market Forecast;
3. Review of Existing and Proposed Generation Sources;
4. Generation Expansion Plan and Production Cost Modeling;
5. Selected Priority Project Evaluation;
6. Implementation Plan;
7. Host Kyrgyzstan Delegation; and
8. Presentation of Report.

This approach is the result of the preliminary information review visit to KSEC by Harza in November 1992. Harza's review of proposed generation sources will be limited to:

- Kambarata Hydroelectric Stations No. 1 and 2 (2,260 MW);
- Upper Naryn Hydroelectric (8) Stations (350 MW); and
- Kirov Hydroelectric Station (21 MW).

Contents of Report

The general outline of the report is as follows:

- Executive Summary

- Foreword

- Chapter 1: Kyrgyzstan Energy Sector
- Chapter 2: Present and Future Electricity Demand
- Chapter 3: The Naryn River System
- Chapter 4: Cost Estimates and Project Scheduling
- Chapter 5: The Kambarata Hydroelectric Projects
- Chapter 6: The Upper Naryn Hydroelectric Projects
- Chapter 7: The Kirov Hydroelectric Project
- Chapter 8: Hydro Operation Studies and Generation Expansion
- Chapter 9: Findings, Conclusions, and Recommendations

- References

Study Participants

The following individuals from the following listed organizations participated in the study.

Kyrgyzstan State Energy Company

Dzhamalbek T. Tuleberdiev, President;
Bolot A. Botbaev, Executive Director on Economy and Foreign Relations;
Alexei G. Ziryanov, Head, Technical Hydropower Center;
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Mr. Alexei Vaseliev, Director of Bishkek Station;
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Tashkent Hydro Design Institute

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Roman A. Veitsman, Chief Expert, Cost Estimating and Construction Scheduling;
Igor B. Turetsky, Chief Expert, Water Supply Facilities and Hydrology; and
Alexander G. Kalashnikov, Chief Expert, Energy Potential Criteria Justification.

Energy System Design Institute

Izolda M. Golvarg, Chief Specialist, Transmission Lines Construction; and
Irina K. Kiyatkina, Chief Specialist, Energy Output Estimation.

Naryn Hydro Energy Construction Company

Individuals from Naryn Hydro Energy Construction Company were consulted regarding construction cost, methods and scheduling:

Vladimir N. Shelvelev, Chief Engineer;
Omurbek Tuleberdiev, Chief, Upper Naryn Production and Technology Dept;
Leonid Varentut, Chief, Production Department;
S.V. Nikolaevich, Chief Engineer;
V.V. Illarionvich, Dept. Chief;
R.I. Usmanovich, Chief of Construction; and
other construction personnel.

Ministry of Economy and Finance, Republic of Kyrgyzstan

Mr. Noruzbay A. Amanalieyev, Deputy Head, Industry Department

Harza Engineering Company

The Harza Team included the following specialists:

Henry Chen, Project Director;
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Peter J. Donalek, Senior Transmission Engineer;
Carl M. Brown, Geotechnical Engineer/Engineering Geologist; and
Judson Woods, Planning Engineer.

Acknowledgements

In addition to the persons directly involved in the study, Harza wishes to gratefully acknowledge the assistance offered by the people listed below:

Meetings were held in Bishkek with:

U.S. Ambassador Edward Hurwitz, United States Embassy, Kyrgyzstan
Vladomir A. Chernitzov, Chief Engineer, Kirov Project
Mr. Ivan Matveevich Guljaev who provided a set of 10 maps on hydropower potential, geology, and seismicity.

The following were met during the site visit to Kirov project:

Kokumbek Tashtanaliev, Chief, MINVODHOZ, Kirov Hydro Complex
Kyrkbek U. Sultanov, Director, Talass Energy Company, KSEC

The following were met in Kara Kul during the site visit to Kambarata and Toktogul:

Bolot I. Imanaliev, Director, Toktogul Hydroelectric Station

Meetings with the following energy sector officials were held in Almaty, Kazakhstan:

Valeri V. Talalaev, President, KAZAKHSTANENERGO;
Boris A. Golovyashkin, Vice President, KAZAKHSTANENERGO;
Alexander N. Evtyushkin, Chief Specialist, Foreign Economic Relations Department, KAZAKHSTANENERGO;
Anatoly V. Glushkoy, Deputy to Chief Engineer, Industrial Union of Electrical and Power Engineering, ALMATYENERGO;
Khamidullin Kim Garifvich, Director, Kazakh Transmission System Design Institute; and
Valery C. Torlambaev; Chief Engineer; Industrial Union of Electrical and Power Engineering.

Meetings were held at the United States Embassy, Kazakhstan with:

Mr. Edward W. Birgells, Project Development Officer, USAID;
United States Ambassador Courtney, US Embassy, Kazakhstan;
Mr. Craig Karp, Economic/Commercial Officer, US Embassy; and
Ms. Gulbarshin M. Bozheyeva, Sciences & Environment Assistant, US Embassy.

Discussions were also held with Mrs. Nandita Parshad of the European Bank for Reconstruction and Development, and Rod Scriban of SNC-LAVALIN.

Conversions, Abbreviations, Acronyms

EBRD	European Bank for Reconstruction and Development
KSEC	Kyrgyzstan State Energy Company
THDI	Tashkent Hydro Design Institute
USAID	United States Agency for International Development

Chapter 1

KYRGYZSTAN ENERGY SECTOR

1.1 Organization

The Ministry of Energy and Fuel Resources is the central administrative body which implements unified policies on energy and fuel resources. The Ministry is organized and functions in accordance with the Constitution of Kyrgyzstan, Presidential decrees, and the laws and regulations of Kyrgyzstan. The Minister is appointed by the President of Kyrgyzstan. The Kyrgyzstan State Energy Company (KSEC) is one of sixteen state-owned energy enterprises organized under this Ministry.

KSEC's President, who is also the current Deputy Minister, is appointed by the Prime Minister. All financial and organizational decisions are taken in agreement with the Ministry. KSEC annual budget is approved by the Ministry of Energy and Ministry of Finance. Day-to-day operations are the responsibility of KSEC's management. KSEC has a total staff of about 15,000. Plans are under to convert KSEC to a joint stock company in 1994. There are currently twenty-two regional subsidiaries and specialty institutes organized under the KSEC.

1.2 Energy Sector Resources and Demand

The Republic of Kyrgyzstan is a mostly mountainous region situated between China, Tadjikstan, Uzbekistan, and Kazakhstan. Only about one-third of its population of 4.5 million live in urban areas. It has considerable hydro resources, of which 90% of the estimated potential has yet to be exploited.

Basic indicators of Kyrgyzstan's fuel and energy industries (from the report entitled "The Energy Program of Kyrgyzstan", Table 1, p. 7) are shown on Table 1-1.

Prior to 1990, the Republic of Kyrgyzstan's fuel and energy resources grew at an average 3% annually, and domestic consumption (demand) of fuel and energy also grew by 2-3% on an average annual basis. The domestic growth of demand for electricity in 1990 (4.4%) and 1991 (6.4%) was somewhat higher than for other energy sources, and this demand grew most in the residential sector, at a rate of 17.5% and 31%, respectively.

Basic Indicators of the Development of Kyrgyzstan's Fuel and Energy Industries 1990 to 1992

	Indicator	Unit of Measurement	1990	1991	1992	1991 vs. 1990	1992 vs. 1991
1	Total Consumption of Energy Resources	thous. tons fuel equiv.	12,446	11,714	10,249	82.3	87.5
	Electrical Power	mil. kW hrs	9,257	9,762	9,760	105.4	100.0
	Fuel	thous. tons fuel equiv.	9,437	8,541	7,077	75.0	82.9
	Coal	thous. tons	4,880	4,400	4,300	88.1	97.7
	Natural Gas	mil. cubic meters	2,136	2,214	1,947	91.2	87.9
	Liquefied Natural Gas	thous. tons	116	125	80	68.1	84.3
	Fuel Oil	thous. tons	1,006	887	570	56.7	84.3
	Diesel Fuel	thous. tons	599	562	390	65.1	69.4
	Automotive Gasoline	thous. tons	707	568	370	62.3	65.4
	Aviation Kerosene	thous. tons	118	105	60	51.4	57.1
	Other Petroleum Products	thous. tons	247	265	80	32.4	30.2
2	Total Production of Energy Resources	thous. tons fuel equiv.	6,878	6,943	5,805	84.4	83.6
	Electrical Power Generation	mil. kW hrs.	13,235	14,055	11,960	91.7	85.1
	Coal Mining	thous. tons	3,742	3,483	2,151	60.1	61.8
	Oil Production	thous. tons	155	143	118	80.6	82.5
	Gas Production	mil. cubic meters	96	70	72	70.9	102.9
3	Total Energy Imports	thous. tons fuel equiv.	9,161	8,754	7,289	79.3	83.0
	Electricity	mil. kW hrs.	3,220	4,123	3,600	111.7	87.3
	Coal	thous. tons	2,840	2,157	2,800	98.6	129.8
	Natural Gas	mil. cubic meters	2,040	2,144	1,879	92.1	87.6
	Liquefied Gas	thous. tons	118	125	80	68.1	84.3
	Petroleum	thous. tons	2,675	2,385	1,470	55.0	61.7
4	Total Energy Exports	thous. tons fuel equiv.	3,593	3,983	2,825	78.6	70.9
	Electricity	mil. kW hrs.	7,198	8,416	5,980	83.1	71.1
	Coal	thous. tons	1,720	1,740	1,170	65.0	87.2
	Oil	thous. tons	155	143	118	80.6	82.5

Since 1990, there has been a decline in production, consumption and import levels for the Republic's overall fuel and energy resources, across-the-board, due to a general decline in the economy and increasing costs of production, including fuel costs. Overall fuel and energy resources declined 17% between 1990 and 1992, while consumption dropped by 18%. The 1992 primary energy balance is represented on Exhibit 1-1.

Domestic energy production fell in all areas in 1992 due to the economic situation. In the first nine months of 1993, coal output decreased by 21%, oil production fell by 11%, and gas production by 42%. Even electricity generation declined by 18%.

The domestic energy production decline paralleled falling industrial production. The decline occurred due to the greatly altered economic realities for Kyrgyzstan before and after it became independent in September 1991. Before it became independent, "in the Soviet fuel and energy system, Kyrgyzstan was assigned the role of a consumer of Russian and Kazakh coals, Turkmenistan and Uzbek gas, and Russian, Kazakh and Uzbek oil" (Energy Program, p. 1). After September 1991, its economy deteriorated due to the collapse of the integrated trading networks of the former Soviet Union and the move to establish oil and gas trade at world market value prices. The Energy trade balance for 1992 is represented in Exhibit 1-2.

1.2.1 Coal Resources

The Republic of Kyrgyzstan has 21 identified coal deposits (hard coal and lignite) with indicated reserves of 1,268.8 million tons of Category A, B, and C1 reserves, 783.5 million tons of Category C2 reserves, and 138.2 million tons of potential reserves. Commercial reserves at active fields are estimated at 141.4 million tons, of which about half (77.7 million tons) are located in surface mines.

Coal deposits are located in four basins: 1) the South Fergana Lignite Basin with geological reserves of 440 million tons; 2) the Northern Fergana Bituminous Coal Basin with geological reserves of 300 million tons; 3) the Uzgen Bituminous and Coking Coal Basin with geological reserves of 750 million tons; and 4) the Kavak Lignite and Bituminous Coal Basin with geological reserves of 800 million tons. Currently, more than 660 million tons indicated reserves have been developed and prepared for mining in Kyrgyzstan (Energy Program, p. 52).

The Republic's coal production facilities have a total production capacity, including at both surface and underground mines, of around 4.05 million tons. Output, however, declined 40% from 1990 to 1992, from 3.742 million tons to 2.1 million tons. A 25 percent drop occurred in coal production in the first quarter of 1992 alone. In 1992, about 53% of the domestic coal production supplied the domestic coal market for the Republic, while the remaining 47% (1.05 million tons) of the coal output was exported. When operating at

normal capacity, Kyrgyzstan's coal production can meet around 70% of the domestic demand while exporting about 1,700 million tons of coal annually.

The steady decline in output from the coal mines is attributed to an overall inefficiency in the mining and processing activities. The coal mines are small, and require major investments to modernize their extraction methods, enable them to efficiently extract deeper deposits, and thus expand their output. However, the declining productivity of the mines was further exacerbated by the (financial) inability for the Republic to obtain an adequate level of raw materials and supplies needed for extracting the coal, which must be imported.

In 1992, Decree No. 275 was issued, requiring the coal industry to be self-financing by setting coal prices based on current and future supply costs (Decree No. 275, June 4, 1992). Despite this resolution to make the coal industry financially self-sufficient, the Government of Kyrgyzstan plans to subsidize the coal industry during the years 1993 to 1995 to achieve improvements in the production capacity. The goal of this support is to increase production to 3.0 million tons in 1995.

With improvements in the coal production capacity expected to result in higher output levels starting in 1995, Kyrgyzstan expects domestic coal production capacity to reach 6.17 million tons between 1995 and 2000, with the average annual output during this period between 4.2 and 5.3 million tons. Around 1998, the Republic's coal production is anticipated as being capable of meeting 100% of its domestic demand (5.0 million tons). Similarly during the decade between 2001 and 2010, coal production capacity is expected to attain a level between 6.2 and 8.12 million tons, with an average annual production of 5.4 to 7.0 million tons.

The total demand for coal in Kyrgyzstan reached 4.88 million tons in 1990, fell to 4.4 million tons in 1991, and further dropped to 3.4 million tons in 1992 (See Table 1-1.). Most of the domestic demand is in the residential sector, which uses the fuel for space heating and cooking purposes. The Government is aiming to substitute electricity for heating furnaces in households, which, along with the expected trend in rising coal prices, curb the growth of coal demand to a modest increase, despite the prospect of increased coal utilization in industrial and district heating boilers (replacing oil and gas).

If the coal mines are operating at normal production levels, they would be able to supply about 70% of the domestic demand for coal, as used in industrial and district unit boilers, utility powerplants, and households. The demand forecast for coal consumption is expected to rise from its 1992 nadir, to gradually increase to 3.5 million tons in 1995, 5.3 million tons by 2000, and 6.4 million tons by 2010. However, coal's market share may peak in 1993 in terms of total energy demand, before stabilizing at 35-36% from the year 2000 to 2010.

The long-term demand for coal as a powerplant fuel, expected to grow modestly from 25.1%

(representing 1.08 million tons) of the total domestic coal demand in 1993 to 27.7% (1.3 million tons) in 1995, after which it is expected to decline to 20.8% (1.1 million tons) by 2000, and 15.6% (1.0 million tons) in 2010. This decline in the share of coal for fuelling powerplants will be somewhat offset by its increasing share as the fuel for industrial and district unit boilers, steadily rising from an estimated 19.5% (0.84 million tons) in 1993 to 45.3% (2.9 million tons) in 2010. However, the Bishkek Power-and-Heating Plant will itself require around 1 million tons per year by the year 2000.

Table 1-2

Actual and Forecast Energy Demand
(MTOE)

Year	Electricity	Coal	Gas	Oil	Total Energy
1989	0.61				
1990	0.64	3.25	1.92	2.68	8.49
1991	0.68	2.93	1.99	2.39	7.99
1992	0.67	2.87	1.75	1.47	6.76
1993	0.72	2.87	1.98	1.72	7.29
1994	0.77	3.00	2.21	1.87	7.85
1995	0.84	3.13	2.34	2.07	8.38
2000	1.25	3.53	2.88	2.35	10.02
2005	1.67	3.80	2.88	2.55	10.90
2010	2.00	4.27	2.88	2.75	11.90

To meet demand in the northern regions of the Republic, where 70% of the coal is consumed, coal was traditionally imported from Kazakhstan and Russia, at higher prices than the domestically-produced coal. The prices of imported coal are expected to rise, as the republics exporting the coal to Kyrgyzstan adjust their prices in line with international coal prices. If domestic coal production could be stabilized at 3.3 million tons per year, another 1 to 2.3 million tons of imported coal would be necessary from 1993 to the year 2000 in order to meet the forecast average annual demand, which ranges from 3.0 million tons in 1993 to 5.3 million tons by the year 2000, and possibly reaching a stable level at 6,000 to 6,500 million tons after 2005. (See Table 1-2 for forecasted demand.) The cost of the imported coal through 2005 is estimated at between 20 to 50 billion rubles, which would

be an economic hardship for the Republic. Thus, the Republic of Kyrgyzstan has determined that it must increase productivity and output of its domestic coal mining industry by modernizing it and deregulating the prices in order to allow it to be able to obtain the financing for necessary investments from domestic, FSU and overseas private investors. If successful, domestic coal production will be able to meet 81.5% (at an output of 5,300 million tons per year) of domestic demand by the year 2000 (Energy Program, pp. 49-63).

1.2.2 Oil and Gas Resources

The magnitude of oil and gas reserves located in Kyrgyzstan is uncertain. Recent discoveries of large hydrocarbon deposits in the neighboring countries of Uzbekistan and China may indicate the presence of major oil and gas reserves in Kyrgyzstan Fergana Basin.

The oil and gas industry is producing oil and gas currently from commercial reserves estimated at 14.6 million tons of oil and 4.9 billion cm^3 of gas. Currently, Kyrgyzneft Industrial Association of the Ministry of Industry is exploiting 7 oil, 2 oil-and-gas, 1 oil-and-gas condensate, and 3 gas fields. Drilling has been completed and production is in late stages at the largest fields: namely Izbaskent; Mayli-Suu IV; Eastern Isbaskent (horizons V-VI); and Changyrtash. Oil production is falling due to water encroachment and pool depletion.

Another group of fields were discovered from 1974 to 1976: Beshkent-Togap; Karagachi; Tamchi; Chigirchik; and Northern Karakchikum. Drilling in these fields is not complete but production is already declining.

Currently the oil and gas industry plays a very minor role in supplying fuel for Kyrgyzstan. Its share of the production of fuel and energy resources is only 5%, while its share of consumption is less than 1% (Energy Program, p. 64). Practically all of the Republic's oil and gas requirements were imported from other Former Soviet Union (FSU) republics. Meanwhile, all of the oil produced in Kyrgyzstan–which was minor in scale due to the FSU's investment interest in favor of oil and gas field development in other FSU republics–was exported, because the Republic lacked any refinery facilities. Although oil and gas production in Kyrgyzstan has declined steadily over the past 30 years, since 1990, the decrease has been more rapid. The level of production from the 438 operating wells in the sector brought production down from 155 thousand tons in 1990, to only 143 thousand tons/year (0.9 tons or 3,000 bbl/day) of oil in 1991, and 118 thousand tons in 1992. Overall oil production fell by 19% between 1990 and 1992, output for oil in 1992 was 70% of the 1990 output. For gas, the 1990 gas production was 96 million m^3, falling to 83 million m^3 in 1991 and 72 million m^3 in 1992, which was 71% of the 1990 production level (Energy Program, pp. 5,7,64). As a percentage of total fuel and energy production in Kyrgyzstan, oil and gas represents only 5%.

In the 1993-1995 period, the Government intends to promote the active exploration for new reserves, expand production at existing facilities, and structure a refining industry, which has heretofore been non-existent in Kyrgyzstan (Energy Program, p. 14). Despite these efforts, the Government expects that oil production will remain at 118-150 thousand tons from 1993 through 2010, and gas production will continue to decline to 55 million m^3 in 1993 and 30 million m^3 in 1995, before turning around and increasing to 50 million m^3 in 2000 and 100 million m^3 in 2010.

As of 1992, the share of oil in domestic fuel and energy consumption was only 1% of the total, and, since oil was exported to Uzbekistan for refining, was attributable to the gas which met only 19% of the gas demand in the southern region of the Republic, or 3% for the overall gas demand of the Republic (Energy Program, p. 64). The gas distribution infrastructure only exists in limited areas of the Republic.

The demand for oil and oil products in 1990 was 2,677 thousand tons, of which 1,006 thousand tons (about 40%) was fuel oil alone, and 60% (1,605 thousand tons) was for fuel oil and diesel fuel combined. The demand for oil decreased consecutively over the next two years, dropping to 2,388 thousand tons in 1991 and 1,470 thousand tons in 1992. In 1993, the demand for fuel and diesel oil is expected to be 1,090 thousand tons, representing almost two-thirds of the 1,660 thousand tons of total oil demand. See Table 1-2 for predicted oil demand levels. The power-and-heating plants in the cities of Bishkek, Osh, Kara Kol, Kyzyl-Kiya, and Kara-Kul (Energy Program, p. 19)–which provide about 40% of the Republic's heating requirements–are powered mainly by imported coal, oil, and gas. These energy plants are experiencing rapid rises in the cost of fuel, from 0.9 kopecks per kWh in 1990 to 54.4 kopecks per kWh in 1992, an increase of 5800%, which has led to efforts to substitute hydropower or other fuel sources (Energy Program, pp. 7,20). Two of the power-and-heating plants also have an electric generating capacity of about 700 MW.

The power-and-heating systems were developed due to lack of sufficient domestic fuel production output for heating purposes on a decentralized basis. The heating capacity of these systems averages between 5,500 and 5,700 gigacalories per year, which represents 39% of the thermal energy consumed by Kyrgyzstan.

Kyrgyzstan forecasts rising oil demand in 1994 and 1995, reaching 1,400 thousand tons and 1,450 thousand tons respectively, which will be met by increasing imported oil products (while domestic production remains flat and destined for export markets over this period).

To expand the utilization of gas, more infrastructure needs to be developed, as well as rational and legal bases for the gas distribution utilities to operate. In particular, the finances of the domestic gas suppliers has been hurt by delayed payments by customers, inadequate supplies of materials and equipment for the system, and increasing price for gas supply, and the turndown in gas consumption as customers–including powerplants–seek less

expensive fuels. Nonetheless, the Government has determined to keep gas as an option in order to have a diversified fuel base, and to obtain the environmental benefits from this clean fuel. The construction of the Bishkek Power and Heating Plant No. 2 will be fired by gas, and is expected to come online in the latter half of this decade.

The demand forecast for gas is expected to rise from 1,354 million m^3 in 1993, to 1,545 million m^3 in 1995 and 2,200 million m^3 in 2000, at which level it will stabilize through 2010. This forecast considers switching a number of existing households from cooking with gas (LNG) to electric ranges, while installing electric ranges in most of the new housing.

1.2.3 Hydro Resources

The total hydropower generating potential from river sources is estimated at 142.5 billion kWh, according to hydrological surveys undertaken by the Government. The potential hydroelectric capacity of Kyrgyzstan, which has many river resources, is estimated at about 26,000 MW. The Hydropower Planning Institute is planning 95 hydropower plants with a total of 11,350 MW of capacity on the rivers (Energy Program, p. 23).

Kyrgyzstan has an installed hydroelectric capacity of 2,740 MW, out of a total electric supply capacity of 3,414 MW. Almost 2,600 MW of installed hydropower capacity is currently located along the Naryn river. There is a reservoir at Toktogul which has long-term storage capacity.

Current Government plans include 6,800 MW to be developed over the period extending until 2010. The 1992 plan for bringing new capacity online between 1993 and 2010 includes the Lower Naryn, Kambarata, Upper Naryn, Kokmeren, Karaman, and Kulanak hydropower plant cascades, and 10 or more small hydro plants.

Of the total electric generation in Kyrgyzstan in 1992, about 77.4% or 9,340 mkWh (of a total 12,060 mkWh) will be generated by hydroelectric plants (Energy Program, p. 19).

One characteristic of the hydroelectric power in Kyrgyzstan is that it is connected to a regional grid connecting several Central Asian Republics, and serves the Republics of Uzbekistan, Turkmenistan and Kazakhstan with vital irrigation services. The irrigation requirements are heaviest during the summer crop months, but the demand for electricity in Kyrgyzstan is greatest in the winter months. The Government plans to promote electric space heating by industrial, commercial and residential consumers will further accelerate the winter production shortages.

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1.2.4 Other Renewable Resources

During the 1993 to 1995 timeframe, the Government of Kyrgyzstan intends to develop a policy for the promotion of non-traditional, alternative energy sources: i.e., solar, geothermal, wind energy, mini-hydro. Currently, none of these resources have been utilized in Kyrgyzstan. The potential for solar energy generation in populated areas is estimated at 50 billion gigacalories; geothermal potential is estimated at 40 million gigacalories per year. Wind energy potential is calculated at 3 trillion kWh in areas below the 500 meter altitude. Small stream hydropower potential is estimated to be 1.5 GWh (Energy Program, p. 78).

It is anticipated that 10% of the growth in energy demand from 1995 through the year 2010 will be met by these resources. The Kun Business Project is charged with this development effort (Energy Program, p. 18).

1.3 District Heating

Two major district heating systems that produce electricity as a byproduct have been installed in the cities of Bishkek and Osh. These plants are commonly referred to as Power and Heating plants. These plants, in addition to supplying hot water for heating purposes, also supply steam for industrial purposes. Also, there are stand alone district heating boilers which do not generate electricity. These are planned or installed in the districts of Kyzyl-Kiya, Karakol and Karakul. The planned output of thermal energy by several of these heating plants operated by the Kyrgiz Energy Company is shown in Table 1-3.

Table 1-3

Planned Output of District Heating Powerplants

	1995	2000	2010
Bishkek No. 1			
Installed Capacity (MW)	701	591	369
Annual Generation (GWh)	3900	3350	2240
Annual Thermal Energy (1000 gcal)	4886	4425	3040
Peaking Boiler (1000 gcal)	800	800	800
Bishkek No. 2			
Installed Capacity (MW)	--	180	720
Annual Generation (GWh)	--	973	4434
Annual Thermal Energy (1000 gcal)	--	2910	3790
Osh			
Installed Capacity (MW)	50	50	80
Annual Generation (GWh)	250	250	350
Annual Thermal Energy (1000 gcal)	1473	1935	1935
Kyzyl-Kyl			
Annual Thermal Energy (1000 gcal)	60	60	60
IPES			
Annual Thermal Energy (1000 gcal)	319	319	319
Karakol			
Annual Thermal Energy (1000 gcal)	--	480	1200
Komosmol			
Annual Thermal Energy (1000 gcal)	22	115	115

In summary, the heating system operated by the Kyrgiz Energy Company generates nearly 5700 gigacalories of heat per year, or nearly 39% of all the thermal energy consumed by the Republic. The total length of the heating circuit is approximately 460 kilometers.

There are several industries which own cogeneration plants commonly referred to as Block Stations. These Block Stations generate sufficient thermal energy and electricity needed to operate each of these industrial facilities.

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1.3.1 Bishkek Power and Heating Plant No. 1

The present installed electric capacity of this plant is 624MW. Currently it has a capacity to supply 1720 giga calories/hr of thermal energy. It has a total of ten steam turbines and 24 boilers. All the boilers are designed to burn coal, oil and natural gas. The technical details of these turbines and boilers are shown in Exhibit 1-3 and 1-4. Almost all the equipment was manufactured in the former Soviet Union. An additional turbine of nearly 90 MW capacity is expected to go into commercial service during 1994.

This plant is experiencing several difficulties in obtaining good quality coal and hence it has been forced to utilize expensive natural gas. Exhibit 1-5 shows the quantities of coal, oil and gas used from 1985 to 1992 and projected utilization of these fuels through the year 2010. Nearly half the coal and all of the gas and oil required to operate this plant is imported.

The boilers are experiencing severe maintenance problems because of the poor quality high (40%) ash content coal it receives from Kazakhstan and high (>2%) sulfur fuel oil it receives from refineries in the former Soviet Union.

General practice for maintenance is as follows:

> Once in four years, each boiler undergoes extensive rehabilitation, including replacement of heating surfaces;
>
> Each turbine is inspected and rehabilitated every five years;

The purpose of this extensive maintenance is to achieve operating efficiencies within 5% of the original design.

In addition, every year boilers and turbines are inspected for preventive maintenance.

Nearly 90% of all the material, including spare parts required to maintain this plant, will have to be imported from Russia, Kazakhstan, Ukraine and Byelorussia. Prior to the break up of the Soviet Union, major maintenance of this plant was undertaken by a Central Remont Company which now no longer exists. Therefore, Kyrgizstan needs to import specialized skills from Russia and other Republics for major rehabilitation of boilers and turbines.

Exhibit 1-6 shows historical monthly generation of electricity and thermal energy from this power station. For example, in 1990, this station generated nearly 3960 million kWhrs of electricity and 4360 gigacalories of thermal energy.

In 1990, this station used 829,000 tons of coal, 232,000 tons of oil and 964 million cubic

meters of natural gas.

The estimated gross heat rate for electricity generation at full load electricity is 2251 kcal/kWhr which is high for a cogeneration plant.

This station provides nearly 70% of all the heating requirements of Bishkek city.

1.3.2 Osh Power and Heating Plant

The installed electric capacity of this plant is 50 MW. Its heat generating capacity is nearly 251 gigacalories/hr. The plant has three boilers and two turbines and has plans to add an additional 30 MW in 2001. The plant uses oil and natural gas to generate steam. The technical details, historical and planned fuel utilization and historical electricity and thermal generation data are shown in Tables 2-6

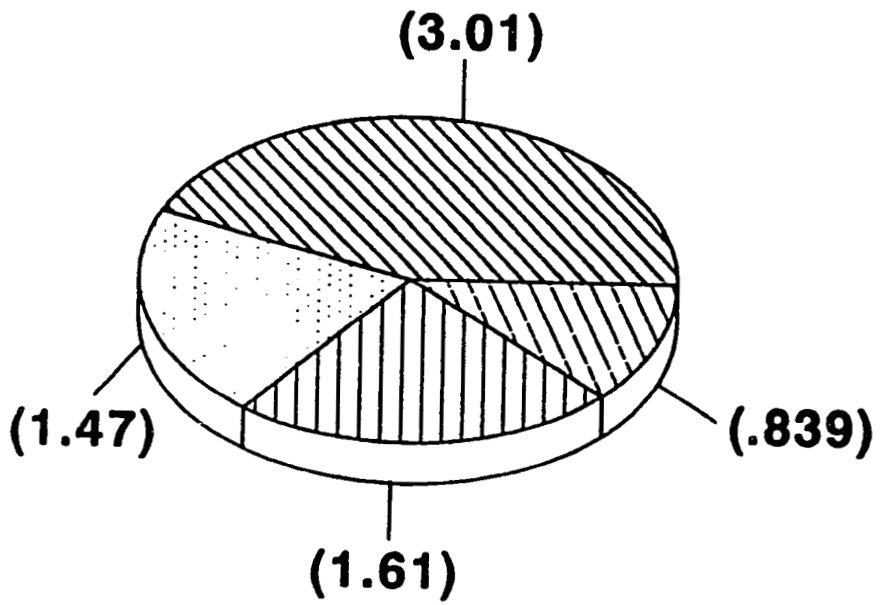
In 1990, this station produced nearly 240 million kWhrs and 1031 gigacalories of thermal energy. In the same year this station used 118,000 tons of oil and 51 million cubic meters of natural gas.

The estimated gross heat rate at full load chargeable to electricity is 1779 kcal/Kwhr.

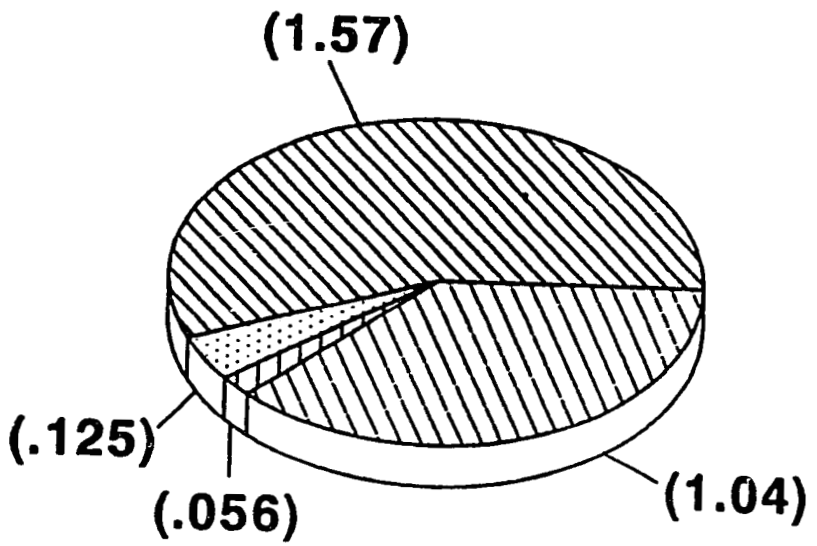
1.3.3 Seasonal Variation

Exhibit 1-6 indicates monthly thermal energy data for the years 1987 to 1992. Assuming 1990 to be a typical year, the thermal energy requirement during January 1990 was about 600 and 148 gigacalories, and the corresponding electricity production was about 400 and 30 million kWhrs for the cities of Bishkek and Osh, respectively. The same stations produced about 250 and 50 gigacalories and 250 and 14 million Kwhrs during June 1990, respectively.

KYRGYZSTAN
Primary Energy Balance 1992
(million tons of oil equiv./yr)



Consumption



Production

Oil & [illegible]cts | Gas | Electricity

EXHIBIT 1-1

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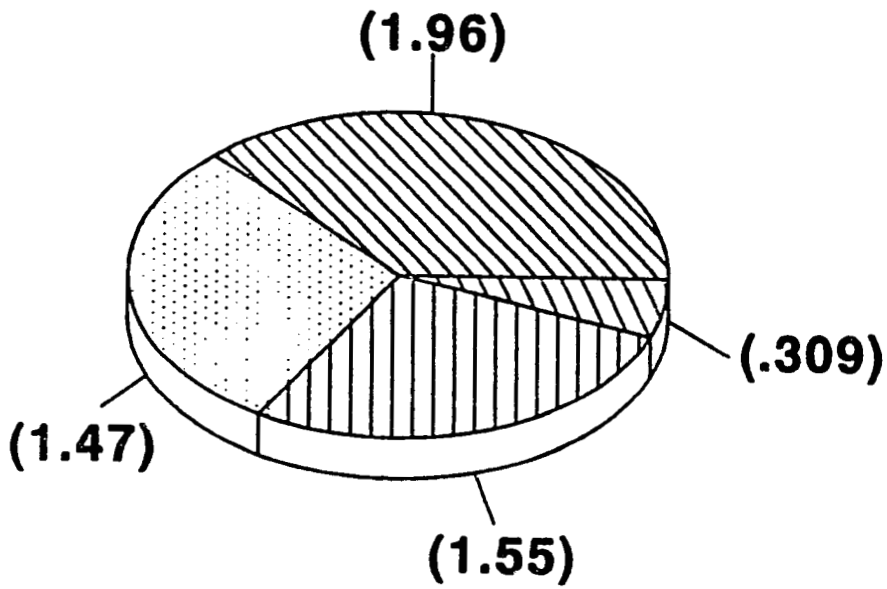
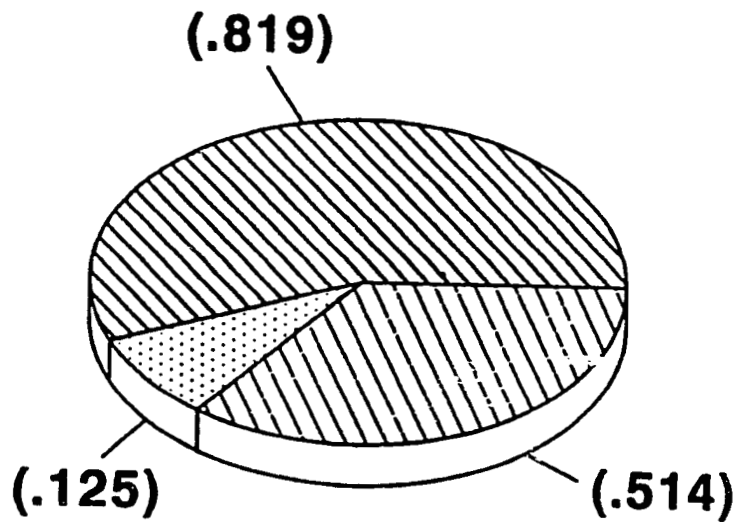
KYRGYZSTAN
Energy Trade Balance 1992
(million tons of oil equiv./yr)



Imports



Exports

Coal | Oil & Products | Gas | Electricity

[illegible]ce: The [illegible] P[illegible] of [illegible] 1992.

EXHIBIT 1-2

TURBINE/GENERATOR OPERATING DATA OF EXISTING EQUIPMENT

	Year	No. of Hours	Installed Maximum Load (MW)	Actual Minimum Load (MW)	Actual Maximum Load (MW)	Pressure Inlet (atm)	Temp. Inlet (C)	Steam Flow (tons/hr)
Bishkek P.S. 1								
PIT-35-90/10 (Y)	1961	224,164	35	14	35	90	540	240
T-25-90(Y)	1962	226,320	25	10	25	90	540	150
PIT-50-90/13 (Y)	1963	210,345	50	20	50	90	540	337
T-86-90/2.3	1963	209,967	86	35	86	90	540	408
P-35-90/2.3 (Y)	1965	173,995	35	14	35	90	540	200
T-86-90/2.3	1966	192,602	86	35	86	90	540	408
PIT-60-90/13 (Y)	1970	155,174	60	24	60	90	540	402
PIT-60-90/13 (Y)	1972	157,099	60	24	60	90	540	402
T-86-90/2.3	1975	133,199	86	35	86	90	540	408
T-86-90/2.3	1977	105,305	86	35	86	90	540	408
T-116/130	1994	0	90	36	90	90	540	
TOTAL			699	282	699			
Bishkek P.S. 2								
T-180/210-130-1	1997		180	72	180	130	545	670
T-180/210-130-1	2001		180	72	180	130	545	670
T-180/210-130-1	2004		180	72	180	130	545	670
T-180/210-130-1	2007		180	72	180	130	545	670
TOTAL			720	288	720			
Osh P.S.								
PIT-25-90		105,873	25	10	25	90	540	150
PIP-25-90/10 (Y)		139,700	25	10	25	90	540	150
PIT-30-90	2001	0	30	12	30			
TOTAL			80	32	80			

BOILER OPERATING DATA

		Year Installed	Hours of Operation	Tons per Hour
Bishkek 1				
	BK3-160-100-92C	1960	196,789	130
		1962	187,529	130
		1962	184,972	130
		1963	182,035	140
		1963	181,668	140
		1964	180,803	140
		1965	162,303	140
		1965	164,838	140
		1966	162,212	140
		1967	154,055	140
		1967	157,597	140
		1968	155,499	160
		1968	141,254	160
	BK3-220-100-4C	1970	133,928	220
		1972	124,239	220
		1972	120,777	220
		1975	115,142	220
		1976	111,989	220
		1977	97,400	220
		1978	89,484	220
		1984	41,021	220
		1986	31,049	220
		1987	25,024	220
		1990	13,280	220
Osh				
	BK3-120-100GMO	1966	139,134	120
		1966	146,635	120
		1966	131,645	120

Historical and Planned Fuel Consumption

	Year	Coal 1000 tons	Oil 1000 tons	Gas MCM
Bishkek 1				
	1985	1495.4	321.9	506.6
	1986	1535.6	332.3	491.0
	1987	1518.8	334.3	561.1
	1988	1218.7	259.4	659.6
	1989	1226.5	279.3	792.8
	1990	923.6	232.3	964.3
	1991	895.8	189.5	977.5
	1992	957.0	37.4	688.0
	1993	1076.4	118.0	900.9
	1994	1252.7	135.3	1042.4
	1995	1301.8	140.3	1083.6
	2000	1114.5	120.1	927.6
	2005	920.0	99.3	920.0
	2010	829.1	89.9	692.2
Bishkek 2				
	1995		12.2	25.9
	2000		61.9	671.6
	2005		80.5	861.2
	2010		96.4	1042.2
Osh				
	1985		136.3	
	1986		143.9	
	1987		146.0	26.3
	1988		105.6	58.4
	1989		123.2	51.5
	1990		117.8	51.0
	1991		109.1	56.3
	1992		86.4	52.1
	1994		101.4	112.1
	1995		182.3	125.0
	2000		26.6	289.7
	2005		28.0	296.6
	2010		28.0	296.6

HISTORICAL MONTHLY OUTPUT

BISHKEK - ELECTRIC POWER OUTPUT (GWh)

	JAN.	FEB.	MARCH	APR.	MAY	JUN.	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	ANNUAL
1987	403.6	361.4	384.8	342.8	300.4	280.8	297.1	286.4	320.0	362.8	368.7	392.2	4101.0
1988	384.3	369.6	379.5	329.5	276.2	267.0	265.3	264.0	274.8	316.3	339.3	387.2	3853.1
1989	394.8	350.2	373.4	319.0	311.5	274.4	288.0	287.9	323.1	348.6	362.4	402.6	4035.8
1990	396.8	353.7	386.0	355.6	323.1	252.3	251.9	253.3	294.8	353.6	362.2	377.2	3960.5
1991	372.8	335.2	376.8	325.9	272.9	218.7	253.8	259.6	287.0	328.6	328.9	325.0	3685.2
1992	313.2	271.6	231.1	214.1	202.7	186.2	137.1	123.7	120.0	151.6	181.0	265.4	2397.6

BISHEK - RELEASE OF THERMAL ENERGY (GIGACALORIES)

	JAN.	FEB.	MARCH	APR.	MAY	JUN.	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	ANNUAL
1987	511.1	416.5	430.1	305.6	165.9	166.4	205.4	199.2	209.6	385.7	504.9	486.2	3986.7
1988	506.6	543.3	454.9	271.8	128.3	193.4	193.9	196.1	213.0	332.3	399.8	475.3	3908.7
1989	570.6	538.7	485.6	343.2	216.9	162.6	217.5	226.3	225.3	328.8	481.7	489.6	4286.8
1990	608.5	491.8	468.0	337.2	155.4	195.3	226.7	221.7	236.5	370.6	473.9	574.6	4360.2
1991	640.5	537.4	514.8	317.1	210.3	192.4	224.5	234.7	244.5	344.0	452.6	548.8	4461.6
1992	558.7	463.0	479.9	274.9	197.8	192.8	212.6	211.3	219.1	330.3	392.0	512.5	4044.9

OSH - ELECTRIC POWER OUTPUT (GWh)

	JAN.	FEB.	MARCH	APR.	MAY	JUN.	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	ANNUAL
1987	17.9	18.8	26.6	19.9	17.3	16.8	17.2	17.1	15.8	10.5	21.7	27.1	226.8
1988	27.0	26.5	26.3	17.8	15.8	17.2	16.9	14.9	15.1	17.6	28.8	31.5	255.3
1989	30.2	26.3	30.2	17.1	15.6	17.6	17.4	16.3	13.4	15.9	25.3	26.3	251.7
1990	29.6	24.9	25.2	18.7	16.4	13.8	15.5	16.1	12.2	18.1	23.5	27.9	241.9
1991	28.1	24.7	24.9	15.4	16.8	13.8	15.2	16.1	12.8	14.9	25.1	20.9	228.8
1992	15.0	15.2	26.3	15.3	12.5	15.5	13.5	13.3	10.6	17.8	24.1	25.7	204.9

OSH -RELEASE OF THERMAL ENERGY (GIGACALORIES)

	JAN.	FEB.	MARCH	APR.	MAY	JUN.	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	ANNUAL
1987	127.4	106.4	96.5	70.1	58.5	63.0	63.8	60.5	51.5	63.3	107.0	134.0	1002.0
1988	129.0	116.0	96.4	68.6	60.7	66.7	66.0	55.9	60.0	67.9	91.4	109.2	987.8
1989	134.6	130.0	117.5	72.7	70.1	67.4	64.6	59.0	56.0	70.0	104.0	121.1	1067.0
1990	148.0	121.5	118.0	69.0	62.0	47.5	50.7	51.9	42.1	75.5	110.5	134.3	1031.0
1991	147.0	135.7	124.3	61.6	69.3	56.0	66.6	62.0	55.2	62.5	85.0	104.8	1030.0
1992	81.7	75.6	107.9	63.7	56.7	53.8	47.5	42.5	31.6	59.8	73.4	101.3	795.5

Chapter 2

PRESENT AND FUTURE ELECTRICITY DEMAND

2.1 Introduction

One characteristic of the existing and potential hydroelectric power in Kyrgyzstan is that it is connected not only to the Kyrgyzstan grid but also to a regional grid connecting several Central Asian Republics which serves the Republics of Uzbekistan, Turkmenistan and Southern Kazakhstan. This regional grid is also connected to Northern Kazakhstan and Russia. Potential hydroelectric projects would therefore serve not only the internal electricity demand of Kyrgyzstan but would also continue to provide export capacity and energy to other republics of Central Asia and surrounding countries. In this chapter, an analysis of the historical and future demand is presented not only for Kyrgyzstan but also for export potential.

2.1.1 Forecasting Methodologies

The three main approaches to long term forecasting commonly used in the industry are:

- Macro-Econometric
- End Use
- Trends Based on Historical Data

The econometric methods use macroeconomic data such as GDP, population, personal income, inflation, cost of electricity, cost of other energy sources, cost of money, et cetera.

End use models examine energy patterns by class of customers. Typically the customer classes consist of industrial, agricultural, household (residential), commercial, and public sector. These sector forecasts are developed based on factors such as economic growth, population, et cetera. In developing these forecasts, these sectors are further subdivided into groups with similar consumption patterns. For example, industries can be further classified by type of industry, households further classified as houses with or without electric heat, et cetera.

The Trend Method basically relies on historical data to develop forecasts for energy consumption.

In practice, some combinations of these are used to estimate the annual peak load and the annual energy demand.

2.1.2 Kyrgyzstan "Official Forecast"

The energy consumption forecast ("Official Forecast") developed and approved by the Republic of Kyrgyzstan (The Energy Program of Kyrgyzstan - 1992) calls for fairly strong demand growth, beginning in the near future. In part, this reflects an apparent belief that economic recovery will prove to be imminent and strong. Longer-term, however, there are some serious questions about whether or not these growth rates can be achieved. Assumptions about electricity exports -- another key uncertainty -- also have a strong impact on the forecast.

The "Official Forecast" for electricity consumption for the period of 1993 to 2010 results in average annual growth rates of about 4.7% for the industry sector, 3.75% for the agricultural sector, 9.1% for the residential sector, and 3.6% for the public sector. The average annual growth rate for electricity is 5.86%. The historical electricity consumption for the period 1973-1991 resulted in average annual growth rates of about 3.2% for the industry sector, 8.5% for the agricultural sector, 7.6% for the residential sector, and 4.9% for the public sector. The average annual growth rate for electricity was 5.1%.

In the present, when so little is known about the future path of the economy of Kyrgyzstan, a heavy reliance on assumptions is unavoidable, particularly as they concern the electric utility sector. For example, the ability to convert homes to electricity at a rapid rate and the forecasted path of electricity exports seem optimistic.

Also, reliance on historical data to develop an energy forecast for Kyrgyzstan may not be accurate. The country has just emerged from years of central planning. As a result, the future behavior of the economy is expected to vary from historical patterns. Historical data may not be a reliable indicator of either what will happen to the economy or the responsiveness of organizations and individuals to the changing situations.

Strong demand growth for energy in the next few years reflects expectations of economic recovery, and forecasted levels afterwards are not unrealistic compared to other developing economies. However, it is also the case that energy use has been particularly inefficient in the republics of the former Soviet Union, and a high level of conservation will presumably be achieved as economic reforms take hold, reducing relative demand growth.

There are certain data not available, which leaves open questions about the growth of energy demand in Kyrgyzstan, expected GDP growth, planned industrial activities, plans for energy conservation, civilian conversion of former U.S.S.R. military facilities, future mining

activities, the willingness and ability of neighboring countries to sell fuel, the willingness and ability of neighboring countries to buy electricity exports, the ability of the power sector to expand distribution capacity, the availability of foreign investment to develop hydroelectric power at a rapid rate, the effect of price reform on electricity consumption, and the breakdown by sector of fuel use.

2.1.3 Forecast Scenarios

To reflect the current uncertainties in the short-term and long-term economic forecasts of Kyrgyzstan and of the power exchanges between the various republics of Central Asia and surrounding countries, three scenarios were developed. These three scenarios -- designated Moderate Growth, Low Growth and High Growth -- were developed for the period 1993-2010 to show the range of potential demand.

In view of the dearth of the above economic data and the presence of a number of economic policy uncertainties, the official energy forecast was assumed as a "High Growth" scenario. The two other scenarios -- Moderate Growth and Low Growth -- were developed based on assumptions underlying the high scenario, a combination of the three forecasting methodologies, historical trends and a series of discussions held in Bishkek, Almaty and Tashkent with various representatives of the electric power industry of Kyrgyzstan, Kazakhstan and Uzbekistan to gain an overall understanding of the power supply and demand of the region. Extensive discussions were also held with the KSEC load forecasting group which included a review of their historical and forecasted data.

For the Moderate Growth scenario, it is expected that a continuation of international funding for restructuration and privatization programs in the agricultural and industrial sectors will have a positive impact on economic activities and electricity consumption. It is also expected that the economy will recover from its current downturn by the mid 1990's and then resume its historical growth. For the export market, despite the current decline in power purchases from other republics, it is assumed that the 1988-1989 level of export will resume by 1996. Thereafter, additional power sales with China, Russia and other countries will further increase the export demand.

Under the Low Growth scenario, it is assumed that the economic recovery will take several more years. This scenario reflects the continuation of a depressed economy until 1996-1997. It also assumes a reluctance from the republics of Central Asia to sign long-term purchase agreements with Kyrgyzstan due to their own development of hydro and/or thermal generation resources.

The High Growth scenario represents a more optimistic view of the potential economic development of Kyrgyzstan and electricity export agreements. It assumes a successful

conversion and expansion of existing industries, along with a continuation of efforts to strongly increase electrification of the residential and industrial sectors. The High Growth scenario represents an upper bound estimate of future peak and energy requirements for use in the analysis of potential long-term development of the hydro potential of Kyrgyzstan.

2.1.4 Electricity Tariff

The current tariff for electricity is very low averaging 0.64 cents per kilowatt-hour, representing about 10 percent of the average world price. By comparison, the price of coal and fuel has already reached about 50 percent of the world price and the price of gas about 90 percent.

The rate charged to industrial users has been traditionally higher (0.84 cents) than the rate applied to agriculture (0.50 cents) and residential (0.15 for urban area and 0.12 for rural area).

The tariff is now adjusted quarterly to reduce the amount of government subsidies and cover the production and distribution costs. With the fuel price used in the thermal plants rapidly reaching world price and required investments in the power sector, the rates are expected to increase quickly over the next five years. It should be noted, however, that the existing hydro facilities which provide nearly 80 percent of the current consumption incur only operation and maintenance costs. These facilities have no debt service.

The increase in electricity tariff will have a definite impact on electricity consumption. Due to its current low cost as compared to alternate fuel, electric heat has increased drastically over the past two years. A study performed by the KSEC load forecasting group shows savings of 35 to 40 percent when using electricity for heating and cooking. This advantage will decrease as the price of electricity increases.

2.2 Historical Trends in Electricity Demand and Supply

Table 2-1 summarizes historical electricity demand and supply for the period 1973-1992. The total energy consumption grew from 3,176 GWh in 1973 to 8,129 GWh in 1991 and 8,111 GWh in 1992. As shown in Exhibit 2-1, except for 1992 where there has been a slight decline in total electricity consumption, the average annual growth rate was 5.4 percent for the period 1973-1991.

In Kyrgyzstan, there are four major groups of electricity consumers: industry, agriculture, population, and the public sector. For the period 1973-1991, the average growth rate was

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TABLE 2-1
HISTORICAL ANNUAL SUPPLY AND DEMAND

YEAR	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
Energy Generation	4,017	4,091	4,081	4,510	4,599	6,605	7,467	8,878	10,010	11,154
Thermal	2,580	2,886	3,161	3,123	3,352	3,756	3,641	3,669	3,585	4,735
Hydro	1,436	1,205	920	1,387	1,247	2,849	3,826	5,210	6,426	6,419
Station Use	263	196	197	227	247	251	268	272	270	400
Transmission Losses	336	377	360	422	443	537	530	593	665	732
Consumption	3,176	3,527	3,828	4,095	4,268	4,461	4,614	4,929	5,007	5,292
Industries	1,921	2,112	2,249	2,344	2,369	2,429	2,497	2,632	2,655	2,663
Agriculture	421	509	616	712	819	891	933	1,045	1,055	1,248
Public Sector	474	521	550	603	628	679	702	753	766	738
Population	360	385	414	436	452	462	482	499	532	643
Export (Import)	242	(9)	(305)	(234)	(359)	1,356	2,055	3,084	4,068	4,730

YEAR	1,983	1,984	1,985	1,986	1,987	1,988	1,989	1,990	1,991	1,992
Energy Generation	10,484	10,886	10,217	11,138	9,115	14,010	14,903	13,154	13,972	11,793
Thermal	4,924	4,974	4,963	5,370	5,224	4,108	4,288	4,202	3,914	2,602
Hydro	5,560	5,913	5,254	5,768	3,890	9,902	10,616	8,952	10,058	9,190
Station Use	416	436	436	463	477	473	503	498	487	405
Transmission Losses	719	900	915	1,057	873	1,116	1,142	1,035	1,064	1,188
Consumption	5,430	5,913	6,212	6,366	6,624	6,866	7,349	7,643	8,129	8,111
Industries	2,714	2,872	2,960	2,990	3,134	3,258	3,417	3,468	3,509	2,958
Agriculture	1,277	1,485	1,591	1,646	1,611	1,[illegible]1	1,876	1,913	1,986	1,872
Public Sector	755	828	878	910	1,018	1,030	1,111	1,152	1,180	1,331
Population	685	729	783	821	862	897	945	1,111	1,454	1,951
Export (Import)	3,920	3,637	2,655	3,251	1,140	5,555	5,910	3,978	4,293	2,176

TABLE 2-2
MONTHLY ENERGY DEMAND

YEAR	MONTH	Industry	Agri-culture	Public Sector	Population Urban	Population Rural	Total	TOTAL
1990	JAN	358.3	179.3	117.3	51.9	66.1	118.0	772.9
	FEB	310.4	169.6	118.7	46.0	58.0	104.0	702.7
	MAR	298.5	218.3	119.6	66.7	11.7	78.4	714.8
	APR	284.6	154.6	105.4	42.1	40.4	82.5	627.1
	MAY	255.8	132.8	92.6	44.2	43.4	87.6	568.8
	JUN	280.2	142.9	74.4	43.2	37.6	80.8	578.3
	JUL	267.8	167.1	65.2	34.5	34.8	69.3	569.4
	AUG	280.2	163.2	71.3	34.0	40.4	74.4	589.1
	SEP	268.2	133.8	75.6	36.1	43.0	79.1	556.7
	OCT	250.1	151.4	106.8	44.8	49.5	94.3	602.6
	NOV	292.1	133.4	95.7	46.4	53.5	99.9	621.1
	DEC	321.3	166.3	109.2	47.7	94.6	142.3	739.1
1991	JAN	351.3	170.9	137.2	66.2	98.7	164.9	824.3
	FEB	310.0	191.6	120.2	47.8	75.6	123.4	745.2
	MAR	302.2	182.0	139.0	47.9	81.2	129.1	752.3
	APR	302.6	160.6	103.4	43.8	67.6	111.4	678.0
	MAY	275.9	164.8	83.1	34.5	61.7	96.2	620.0
	JUN	263.5	160.9	74.4	41.2	57.2	98.4	597.2
	JUL	257.4	158.8	77.1	40.7	64.3	105.0	598.3
	AUG	263.3	159.7	73.0	42.7	58.2	100.9	596.9
	SEP	274.3	135.7	74.5	37.4	58.8	96.2	580.7
	OCT	279.3	171.3	90.9	43.8	41.7	85.5	627.0
	NOV	320.6	151.2	98.0	49.3	85.6	134.9	704.7
	DEC	308.2	178.2	108.7	77.8	131.0	208.8	803.9
1992	JAN	303.8	189.5	135.3	73.8	149.2	223.0	851.6
	FEB	294.1	129.8	137.1	68.9	134.6	203.5	764.5
	MAR	284.1	171.2	154.1	48.7	138.1	186.8	796.2
	APR	253.1	158.8	110.8	50.4	74.0	124.4	647.1
	MAY	240.2	163.7	104.0	51.7	53.8	105.5	613.4
	JUN	222.9	154.6	87.0	48.6	61.8	110.4	574.9
	JUL	227.9	148.9	87.6	40.3	52.1	92.4	556.8
	AUG	225.0	143.4	88.0	40.0	54.0	94.0	550.4
	SEP	224.0	145.0	84.0	41.0	53.3	94.3	547.3
	OCT	209.0	116.0	86.0	71.0	78.0	149.0	560.0
	NOV	238.0	164.0	112.0	132.0	110.0	242.0	756.0
	DEC	251.9	187.0	128.8	153.0	172.3	325.3	893.0
1993	JAN	281.6	182.6	129.1	133.9	187.7	321.6	914.9
	FEB	250.5	201.6	126.8	102.9	165.5	268.4	847.3
	MAR	226.8	163.3	126.3	113.6	195.8	309.4	825.8
	APR	204.3	171.4	98.8	91.0	127.0	218.0	692.5
	MAY	185.9	130.1	91.4	81.1	83.0	164.1	571.5
	JUN	164.1	133.1	93.0	82.8	84.5	167.3	557.5

Year	1987	1988	1989	1990	1991	1992
ENERGY INDUSTRY						
Electro Industry	108,265	121,705	127,550	136,401	148,750	144,928
Oil Industry	44,748	46,850	49,820	51,664	53,184	78,625
Gas Industry	7,748	7,740	8,874	9,714	8,624	7,861
Coal Industry	113,814	119,518	129,629	128,666	128,662	101,626
Subtotal	274,575	295,813	315,873	326,445	339,220	333,040
METALLURGY INDUSTRY						
Metallurgy	358,159	406,521	433,390	460,604	474,324	414,677
Diamond/Gold	38,500	47,065	48,447	49,004	55,138	48,826
Subtotal	396,659	453,586	481,837	509,608	529,462	463,503
MACHINE BUILDING INDUSTRY						
Heavy Machines	6,325	6,554	7,437	6,330	7,073	12,709
Machine Industry	20,362	20,950	22,077	22,090	21,840	19,663
Auto-Agricultural Mach.	160,001	159,601	160,773	154,932	148,426	122,624
Military industry	178,382	184,398	175,024	163,694	159,893	98,411
ElectroTechnical	218,271	222,717	222,606	212,254	194,865	137,320
Boat Industry	63,206	67,079	65,517	64,084	61,666	54,174
Radio	19,067	21,854	23,905	26,090	24,497	18,669
Electronics	55,634	55,696	58,996	59,959	54,658	34,443
Subtotal	721,248	739,049	736,335	709,633	672,918	498,013
BUILDING INDUSTRY						
Government Buildings	89,065	114,819	117,607	99,787	105,095	85,281
Building Materials	303,708	317,296	330,549	335,132	323,034	299,677
Subtotal	392,773	432,115	448,156	434,919	428,129	384,958
CHEMICAL AND WOOD INDUSTRY						
AgroChemistry	242	252	1,047	760	603	941
Wood Industry	14,004	16,598	14,437	1[illegible],750	13,584	16,856
Subtotal	14,246	16,850	15,484	13,510	14,187	17,797
AGRICULTURAL INDUSTRY		500,505	505,300	483,698	325,358	338,545
LIGHT INDUSTRY	333,049	345,830	371,798	364,143	356,914	352,829
TRANSPORT INDUSTRY						
Aviations	15,404	16,240	15,162	16,777	16,810	16,799
Railways	18,492	19,125	19,546	20,417	21,641	18,667
Roads	84,688	67,730	110,232	119,519	130,809	91,722
Transportation Buildings	4,764	3,364	4,398	4,703	5,424	4,800
Subtotal	123,348	106,459	149,338	161,416	174,684	131,988
TOTAL	2,255,898	2,890,207	3,024,121	3,003,372	3,040,872	2,520,673

3.4 percent for the industrial sector, 9.0 percent for agriculture, 8.2 percent for the population sector, and 5.2 percent for the public sector.

Exhibit 2-2 presents the total energy generation for the same period. This includes demand, station use, transmission and distribution losses, and export. Beginning in 1978, Kyrgyzstan has been a net exporter of electricity. Annual exports vary between 2,000 and 6,000 GWh except for the year 1987 when the Toktogul reservoir was being refilled and hydropower generation was curtailed.

Exhibit 2-3 shows the breakdown of electricity generation between thermal and hydro resources. Over the past five years, hydropower generation has comprised about 75 percent of the total generation.

2.3 Recent Trends and Projected Electricity Demand

Table 2-2 summarizes recent monthly energy consumption for the four major customer categories: industry, agriculture, population and public sector. The data shows consumption from January 1990 to June 1993. Population demand is further analyzed under two components: urban and rural.

Exhibits 2-4 through 2-9 graphically show the changes in electricity consumption for each sector. The recent trends and estimates of future consumption are described in the following paragraphs.

2.3.1 Industrial Sector

The industrial sector of Kyrgyzstan includes mining, manufacturing, mechanical and electrical engineering (i.e., the machine building and electro-technical subsector, which includes the assembly of vehicles, washing machines, and other electrical appliances), metallurgy, the chemicals and wood subsector, light industry (textiles), and food processing. Mining and energy alone contributed 6% of GDP in 1991, while the whole industrial sector made up 30% of GDP in the late 1980's and rose to 38% of GDP in 1991 with improved trade conditions. The industrial sector growth rate topped 5% per annum during the last half of the 1980's, decreased by 1% in 1991, and was flat due to the sector's dependence on inter-regional trade, which fell off abruptly in 1992.

Bishkek is the main industrial center, with around 75% of the industrial output produced in its surrounding area.

Historically, the industrial sector in Kyrgyzstan was not sufficiently electrified, and without a national policy to promote electricity use there was no market to encourage the domestic

production of electrical equipment, machinery, and appliances, including switchgear, electric meters, and household appliances.

Industrial demand for electricity, as reported in Table 2-1, rose only slightly from 3,417 GWh in 1989 to 3,509 GWh in 1991, before slumping 15% to 2,958 GWh in 1992, when industrial production was declining due to poor trade conditions and the price of electricity and other fuels was rising. The industrial sector's demand for electricity represented 46.5% of the total electricity demand in 1989, but steadily declined over each of the following years until it reached 36.5% in 1992. The 1992 level was the same as it had been for the industrial sector in the early 1980's.

Table 2-3 shows the breakdown of electricity consumption between the various sub-groups.

A review of Table 2-2 and Exhibit 2-5 shows that electricity consumption continued to decrease during the first six months of 1993. Electricity consumption was 1,312.2 GWh for the first six months of 1993, as compared to 1,598.2 GWh for the first six months of 1992. This represents a decrease of 18 percent.

The Republic's current electrification policy targeted the energy and operating efficiency of the industrial sector, which faced dual problems of declining productivity and increasing energy (including electricity) costs. The electricity demand of the industrial sector is expected to continue to fall over the next two years as adjustments in production and energy conservation programs are implemented. As the sector begins to experience expansion again, the demand for electricity is expected to grow at different rates depending upon the load forecast scenario. Table 2-4 summarizes the results.

Table 2-4

INDUSTRIAL LOAD
HISTORICAL AND PROJECTED DEMAND (GWh)

Year	Low Growth	Moderate Growth	High Growth
Historical Data:			
1980		2,632	
1990		3,468	
1992		2,958	
Projections:			
1995	1,800	2,220	3,350
2000	2,100	2,600	4,400
2010	3,000	4,200	7,100

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For the Moderate Growth scenario, the 1995 demand was assumed to decrease another 25 percent over the 1992 level. For the period 1995-2000, an average annual growth rate of 3.0 percent was assumed. For the period 2000-2010, an average annual growth rate of 5.0 percent was assumed (slightly higher than the 3.4 percent historical annual growth rate of the 1973-1991 period). The industrial demand would decrease to 2,220 GWh in 1995 and increase to 2,600 GWh in 2000 and 4,200 GWh in 2010.

For the Low Growth scenario, the 1995 demand was assumed to decrease another 40 percent over the 1992 level. For the period 1995-2010, an average annual growth rate of 3.5 percent was assumed (same as the historical rate of the 1973-1991 period). The industrial demand would decrease to 1,800 GWh in 1995 and increase to 2,100 GWh in 2000 and 3,000 GWh in 2010.

The High Growth scenario represents the official forecast as shown in the report entitled The Energy Program for Kyrgyzstan. The 1995 demand was assumed to regain the 1990 level. An average annual growth rate of 5.6 percent was assumed for the period 1995-2000, and 4.9 percent for the period 2000-2010. The industrial demand would be about 3,350 GWh in 1995 and increase to 4,400 GWh in 2000 and 7,100 GWh in 2010.

2.3.2 Agriculture

Agricultural consumers' electricity demand grew modestly from 1,876 GWh in 1989 to 1,986 GWh in 1991, then fell by 5.7 percent to 1,872 GWh in 1992. This represented a slight decline in the sector's share of the electricity demand, from 25.5 percent in 1989 to 23.1% in 1992. The agricultural sector suffered declines in its production during 1992, which, along with increasing electricity prices, can explain its decrease in electricity demand in that year. As shown on Table 2-2 and Exhibit 2-6, the agricultural demand remained about the same during the first six month of 1993 as the demand in 1992.

It is assumed that from 1993 forward the agricultural sector will undertake various reforms to improve its efficiency and productivity, and the sector's demand for electricity will increase after these reforms when agricultural and irrigation activities expand. Table 2-5 summarizes the results.

Table 2-5

AGRICULTURAL LOAD
HISTORICAL AND PROJECTED DEMAND (GWh)

Year	Low Growth	Moderate Growth	High Growth
Historical Data:			
1980		1,045	
1990		1,913	
1992		1,872	
Projections:			
1995	1,400	1,680	1,870
2000	1,800	2,250	2,750
2010	2,650	3,350	4,500

For the Moderate Growth scenario, the 1995 demand was assumed to decrease another 10 percent over the 1992 level. For the period 1995-2000, an average annual growth rate of 6.0 percent was assumed to regain the pre-1992 levels. For the period 2000-2010, it is assumed that irrigation pumping will increase to meet the food requirements of a growing population. An average annual growth rate of 4.0 percent was used (only half the historical growth rate was used due to efficiency and electricity conservation). The agricultural demand would decrease to 1,680 GWh in 1995 and increase to 2,250 GWh in 2000 and 3,350 GWh in 2010.

For the Low Growth scenario, the 1995 demand was assumed to decrease another 25 percent over the 1992 level. For the period 1995-2000, an average annual growth rate of 5.0 percent was assumed, and 4.0 percent for the period 2000-2010. The agricultural demand would decrease to 1,400 GWh in 1995 and increase to 1,800 GWh in 2000 and 2,650 GWh in 2010.

For the High Growth or official scenario, the agricultural demand would be 2,380 GWh in 1995 and increase to 3,120 GWh in 2000 and 3,970 GWh in 2010. This corresponds to an average annual growth rate of 5.6 percent for the 1995-2000 period, and 2.4 percent for the period 2000 to 2010.

2.3.3 Population

Household electricity consumption, as shown in Table 2-2, has greatly increased over the past three years: 17.6 percent in 1990, 30.9 percent in 1991, and 34.1 percent in 1992. A

review of Table 2-2 and Exhibits 2-7 and 2-8 shows that the electricity consumption continued to increase during the first six months of 1993. The electricity consumption was 1448.8 GWh for the first six months of 1993 as compared to 953.6 GWh for the first six months of 1992. This represents an increase of 52 percent.

The increase is much higher during the winter months, corresponding to a major use of electric heating appliances. This sharp increase is due to the price differences between electricity tariff and the cost of imported oil, gas or coal used for heating and cooking. Over the past two years, there have been major increases in the price of the thermal fuels, while the price of electricity has remained much more stable.

Although there has been a sharp increase in electricity consumption, the average residential consumption is still relatively low at about 1,500 kWh per household in 1992. The 1992 residential demand was 1,951 GWh for a total number of about 1.3 million households. By comparison, an all-electric average household would use between 8,000 and 12,000 kWh per year.

Despite a generally prevailing trend of increasing household electrification over the past several years, there is a significant amount of electrification yet to be provided in the Republic, especially in rural areas. Distribution grids nearest to many of the rural population centers have been unable to carry the requisite load needed to effectively electrify these households. To encourage household electrification, the Government issued Decree No. 147 in 1990, which offered preferential service to rural households through subsidized rates. The decree was successful in promoting a rapid rise in the level of household electricity consumption, but it consequently caused some problems in the balance of the supply system due to inadequate distribution networks, and it fostered some inefficient utilization of electricity by these new consumers.

A major effort by the government to continue converting households to electricity for heating, cooking and hot water needs is planned for the 1993-1995 period. This policy is being implemented to reduce imported oil and coal used for heating and cooking. However, electricity substitution does not relieve the prospect of overall energy shortages on the near horizon, mainly due to the current constraints to upgrade and extend the distribution network and convert heating systems to electricity on a country-wide basis. There is not a manufacturing base in the country able to produce the electrical home appliances and equipment on the scale needed to quickly promote conversion to electricity, nor are there adequate low-voltage distribution systems to provide electricity to the residential users. It is estimated that the Republic will have to build 49,000 kilometers of 0.4 to 10 kV distribution lines to meet the anticipated electrification needs of households and small consumers by 2010.

Taking these current conversion efforts and constraints into account, a series of projections were made. These projections are based on a stable population until 1995 (immigration and natural growth of the native population balancing emigration) and an average annual growth rate of 2.5 percent until 2000 and 2.0 percent thereafter. The population was assumed to be 4.5 million in 1995, 5.1 million in 2000 and 6.2 million in 2010. The number of persons per household is expected to remain at about 3.5 until 2000 and decrease to 3.3 by 2010. The total number of households would increase from 1.3 million in 1995 to 1.45 million in 2000 and 1.9 million in 2010. Table 2-6 summarizes the results.

Table 2-6

POPULATION LOAD
HISTORICAL AND PROJECTED DEMAND (GWh)

Year	Low Growth	Moderate Growth	High Growth
Historical Data:			
1980		499	
1990		1,111	
1992		1,951	
Projections:			
1995	2,920	3,900	2,970
2000	4,300	5,200	5,730
2010	5,800	8,500	10,570

For the Moderate Growth scenario, the 1995 demand was assumed to double the 1992 level. Thereafter it is expected that the price of electricity will increase in real terms. As a result, substitution to electric heat and cooking will continue, but at a lower rate, and conservation will also have an impact on total consumption. For the period 1995-2000, an average annual growth rate of 6.0 percent was assumed. For the period 2000-2010, an average annual growth rate of 4.0 percent was used. The population demand would increase to 3,900 GWh in 1995 and increase to 5,200 GWh in 2000 and 8,500 GWh in 2010. This would increase the average household consumption from 1,500 kWh in 1992 to 4,475 kWh in 2010.

For the Low Growth scenario, the 1995 demand was assumed to increase by 50 percent over the 1992 level. For the period 1995-2000, an average annual growth rate of 8.0 percent was assumed, and 3.0 percent was assumed for the period 2000-2010. The population demand would increase to 2,920 GWh in 1995, 4,300 GWh in 2000 and 5,800 GWh in 2010.

For the High Growth or official scenario, the population demand would be 2,970 GWh in 1995 and increase to 5,730 GWh in 2000 and 10,570 GWh in 2010. This results in an average annual growth rate of 14.0 percent for the period 1995-2000, decreasing to 6.3 percent for the period 2000-2010.

2.3.4 Public Sector

The trend of the demand in the public sector, consisting mainly of central government and municipal government buildings and publicly-owned facilities, public transportation, street lighting, educational and medical facilities, government-owned shopping centers, et cetera, shows a modest but steady growth rate from 1,111 GWh in 1989 to 1,331 GWh in 1992. However, as shown on Table 2-2 and Exhibit 2-9, the electricity consumption decreased during the first six months of 1993. The electricity consumption was 665.4 GWh for the first six months of 1993 as compared to 728.3 GWh for the first six months of 1992. This represent a decrease of 9 percent.

In the near future, it is expected that the demand of these consumers will remain constant or slightly decrease until 1995. Thereafter, the demand is expected to continue the historical trend, rising slowly. Again, conservation and price elasticity will balance the growth in electricity consumption due to population growth and an increase in government and public services. Table 2-7 summarizes the results.

Table 2-7

PUBLIC SECTOR LOAD
HISTORICAL AND PROJECTED DEMAND (GWh)

Year	Low Growth	Moderate Growth	High Growth
Historical Data:			
1980		753	
1990		1,151	
1992		1,331	
Projections:			
1995	1,200	1,350	1,370
2000	1,390	1,700	1,750
2010	1,900	2,300	2,360

1.4

For the Moderate Growth scenario, the 1995 demand was assumed to remain at the 1992 level. For the period 1995-2000, an average annual growth rate of 5.0 percent was assumed. For the period 2000-2010, an average annual growth rate of 3.0 percent was assumed. The public sector demand would be about 1,350 GWh in 1995 and increase to 1,700 GWh in 2000 and 2,300 GWh in 2010.

For the Low Growth scenario, the 1995 demand was assumed to decrease another 10 percent over the 1992 level. For the period 1995-2010, an average annual growth rate of 3.0 percent was assumed. The public sector demand would decrease to 1,200 GWh in 1995 and increase to 1,390 GWh in 2000 and 1,900 GWh in 2010.

For the High Growth or official scenario, the industrial demand would be 1,370 GWh in 1995 and increase to 1,750 GWh in 2000 and 2,360 GWh in 2010. This corresponds to an average annual growth rate of 3.7 percent for the period 1995-2010.

2.3.5 Total Internal Demand of Kyrgyzstan

The projections made for each customer group were added and are summarized in Table 2-8 and shown graphically in Exhibits 2-10 through 2-13.

Table 2-8

TOTAL INTERNAL DEMAND OF KYRGYZSTAN
HISTORICAL AND PROJECTED DEMAND (GWh)

Year	Low Growth	Moderate Growth	High Growth
Historical Data:			
1980		4,929	
1990		7,643	
1992		8,112	
Projections:			
1995	7,320	9,150	10,070
2000	9,590	11,750	15,000
2010	13,350	18,350	24,000

Under the Moderate Growth scenario, the 1995 demand slightly increased from 8,112 GWh to 9,150 GWh due to the sharp increase in residential load which compensates for the

decline in industrial consumption. The total demand is then expected to increase to 11,750 GWh in 2000 and 18,350 GWh in 2010, corresponding to an average annual growth rate of 5.2 percent for the period 1995-2000, and 4.5 percent for the period 2000-2010. This scenario is more conservative than the projections presented in the report entitled "The Energy Program of Kyrgyzstan". In this report, the 1995 demand is 10,070 GWh, increasing to 15,000 GWh by 2000 and 24,000 GWh by 2010.

Under the Low Growth scenario, the demand would decrease to 7,320 GWh in 1995 and then increase to 9,590 GWh in 2000 and 13,350 in 2010. This would correspond to an average annual growth rate of 5.6 percent for the period 1995-2000 and 3.4 percent for the period 2000-2010, resulting from the assumptions made for each customer group.

For the High Growth or official scenario, the demand would grow to 15,000 GWh in 2000 and 24,000 GWh in 2010. This would correspond to an average annual growth rate of 8.3 percent for the period 1995-2000 and 4.8 percent for the period 2000-2010.

2.3.6 Net Exports

Over the past fifteen years, there has been major exports of electricity during the summer months when water is released for irrigation, and imports of electricity during the winter months to meet the winter demand. As shown in Table 2-1, Kyrgyzstan has been a net exporter of electricity since 1978. Kyrgyzstan intends to continue to exploit its hydroelectric potential through the Integrated Power System shared with neighboring Central Asia republics and surrounding countries. A series of government discussions are being held with these republics and other countries. KSEC is negotiating a contract with China and is looking into the possibilities of wheeling hydro energy through Kazakhstan to Russia and Eastern Europe. Possibilities are also under investigation with India, Pakistan and Afganistan. Kyrgyzstan particularly aims to develop new hydroelectric resources as a means of securing export earnings.

Table 2-9 shows the net power exchanges over the period 1988-1991. There are no long-term power sale agreements between the various parties, but regular quarterly meetings are currently held between the Central Asia republics to discuss power exchanges.

Table 2-9

ANNUAL POWER EXCHANGES (GWh)

Exports to or (Imports) from:	1988	1989	1990	1991
Alma-AtaEnergo	1,335	1,376	1,447	1,872
South KazEnergo	782	679	487	(469)
Talas	(195)	(213)	(227)	(263)
Cyou-Merke-Georg.	178	202	210	218
UzbekEnergo	3,758	4,192	2,384	3,256
TazikEnergo	(303)	(326)	(323)	(321)
Total Net Export	5,555	5,909	3,978	4,293

In 1992, net export decreased sharply to 2,176 GWh, and the downward trend of export is expected to continue in 1993 with a maximum sale of 2,000 GWh. Despite its willingness and capability to export more power, Kyrgyzstan may face resistance from other Central Asian power purchasers on the integrated grid who, with the recent discovery of oil and gas deposits, or due to fuel price adjustments to match international levels, may find it more economic to develop their own domestic fuel and energy resources. For example, Kazakhstan plans to build additional generating capacity: one 3,000-MW coal-fired generating plant in the south and another powerplant of similar size in the northern region, using domestic coal. With the proposed 1150-kV DC transmission line interconnecting the northern and southern regions, future excess power in the northern area could be transmitted to the south, and thus Kazakhstan can achieve self-sufficiency in its energy needs. However, there are a series of environmental problems associated with the development of these coal-fired powerplants and transmission line projects. In addition, major international financing will be required.

Furthermore, some of the Central Asian countries consider it an issue of national security and commercial disadvantage to increase reliance on any single energy resource (hydroelectric power) from foreign suppliers. They have expressed reluctance to sign any long-term power purchase agreements until the costs of their domestically-generated power and other factors become more clear over the course of the next several years.

Taking these constraints into account along with the opportunities for Kyrgyzstan to maintain and increase the export of a clean, renewable resource, a series of projections were made. Table 2-10 summarizes the results.

Table 2-10

NET EXPORT POTENTIAL
HISTORICAL AND PROJECTED DEMAND (GWh)

Year	Low Growth	Moderate Growth	High Growth
Historical Data:			
1980		3,084	
1990		3,978	
1992		2,176	
Projections:			
1995	1,500	2,000	3,089
2000	1,500	2,000	1,775
2010	4,380	6,570	6,529

For the Moderate Growth scenario, the 1995-2000 demand was assumed to remain at the 1992 level. For the period 2000-2010, the level of export would regain the pre-1992 level and increase to a sale of 1,500 MW with a load factor of 50 percent.

For the Low Growth scenario, it was assumed that the export market would continue to decrease to a level of 1,500 GWh for the period 1995-2000. It will only regain the 1992 level by year 2010, corresponding to a 1,000-MW sale at a load factor of 50 percent.

For the High Growth or official scenario, the 2000 demand is projected to be only 1,775 GWh increasing to 6,529 GWh in year 2010.

2.3.7 Total Demand with Net Export

Exhibit 2-14 and Table 2-11 summarize the results.

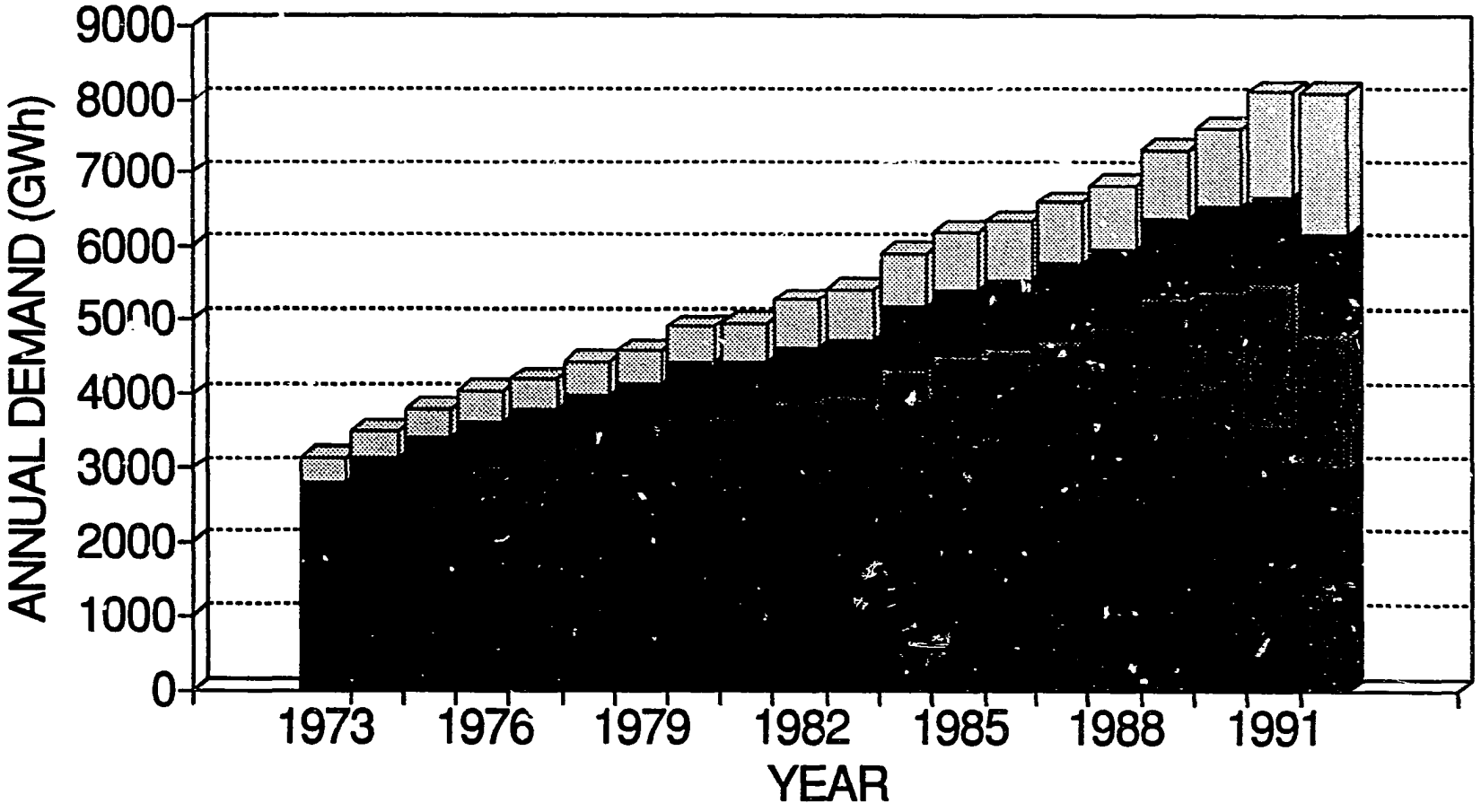
Table 2-11

TOTAL DEMAND WITH NET EXPORT
HISTORICAL AND PROJECTED DEMAND (GWh)

Year	Low Growth	Moderate Growth	High Growth
Historical Data:			
1980		8,013	
1990		11,621	
1992		11,122	
Projections:			
1995	8,820	11,150	13,159
2000	11,090	13,750	16,775
2010	17,730	24,920	30,529

ENERGY DEMAND

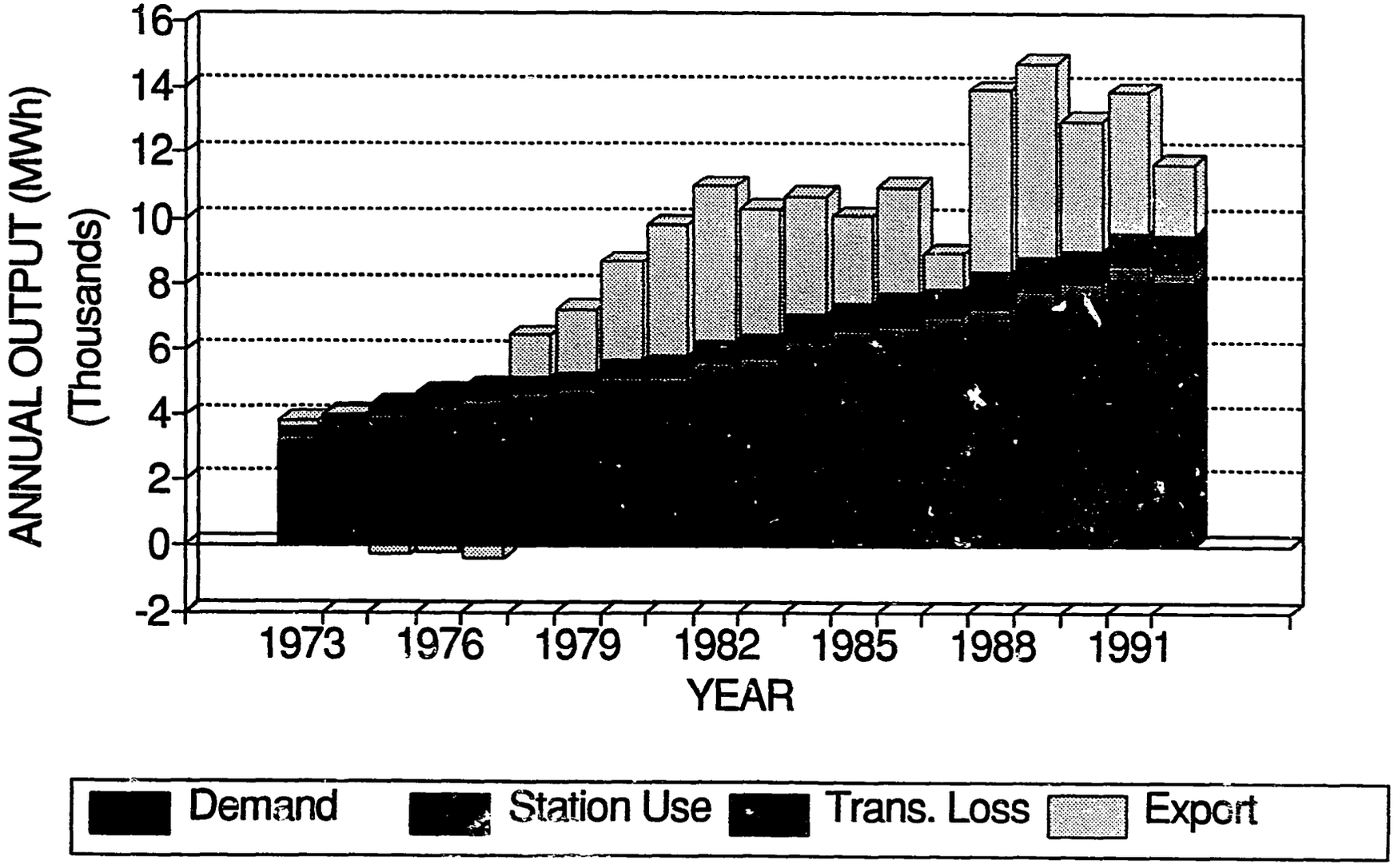
1973-1992



Industries Agric e c es ation

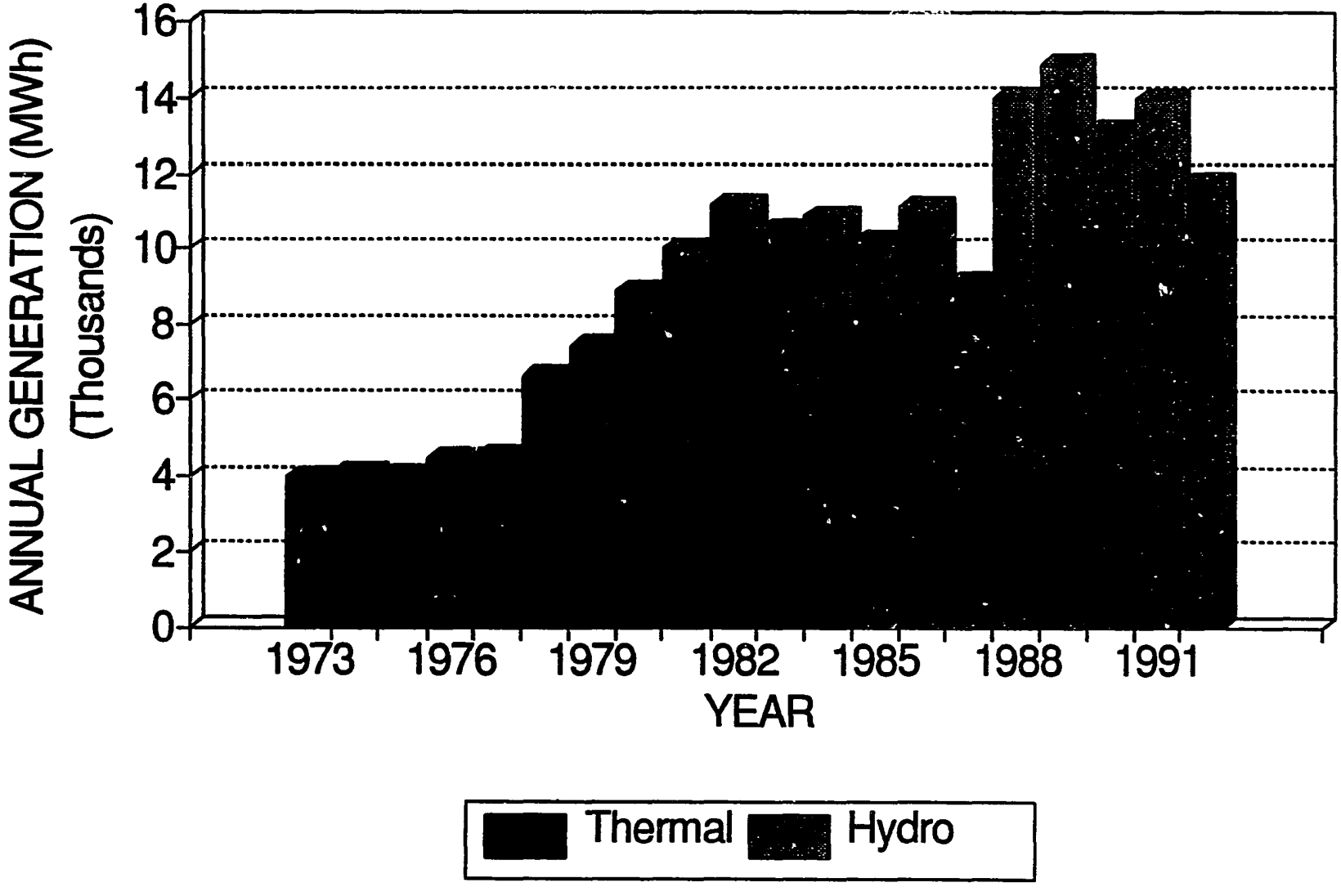
ENERGY OUTPUT

1973-1992



ENERGY GENERATION

1973-1992



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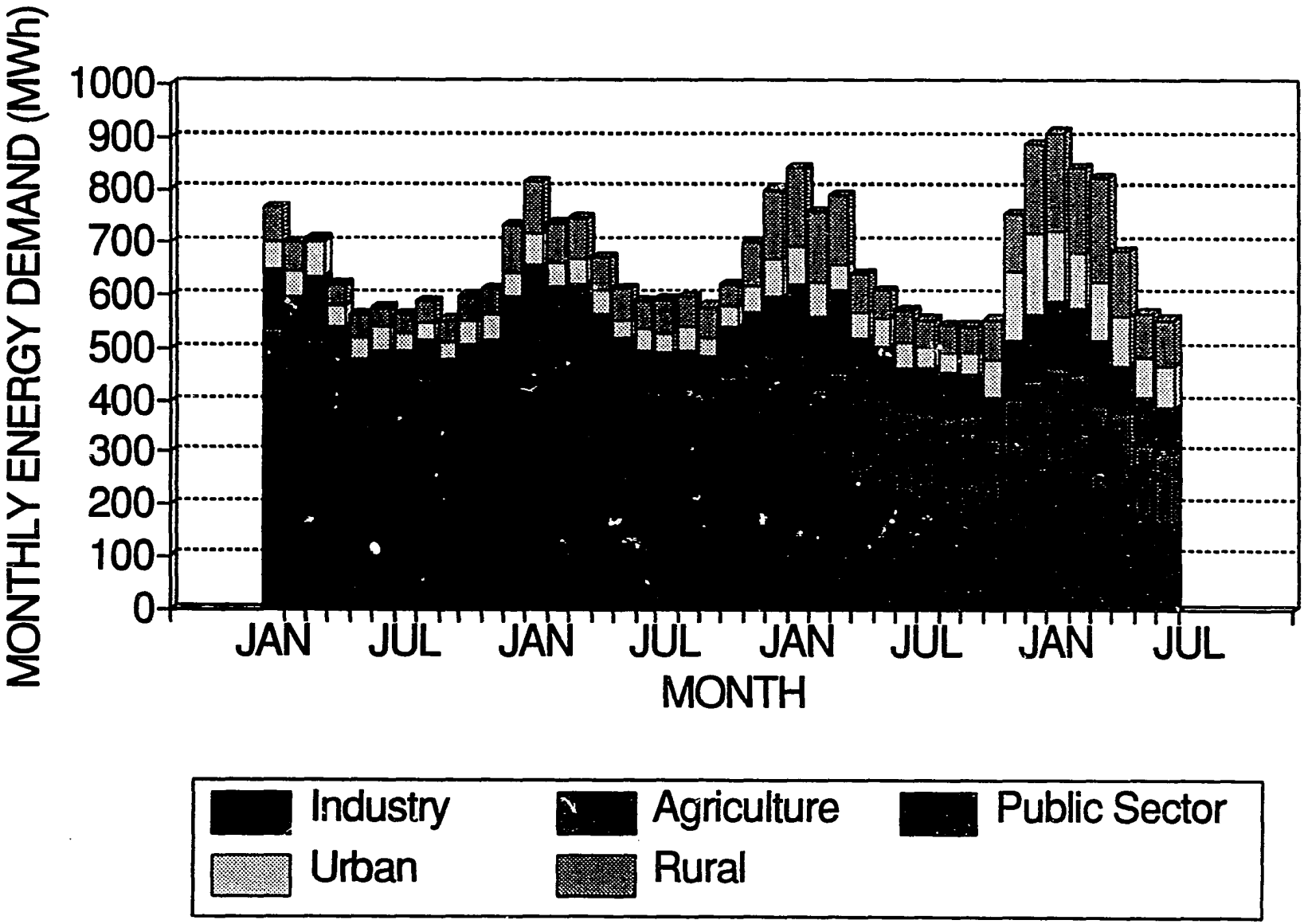
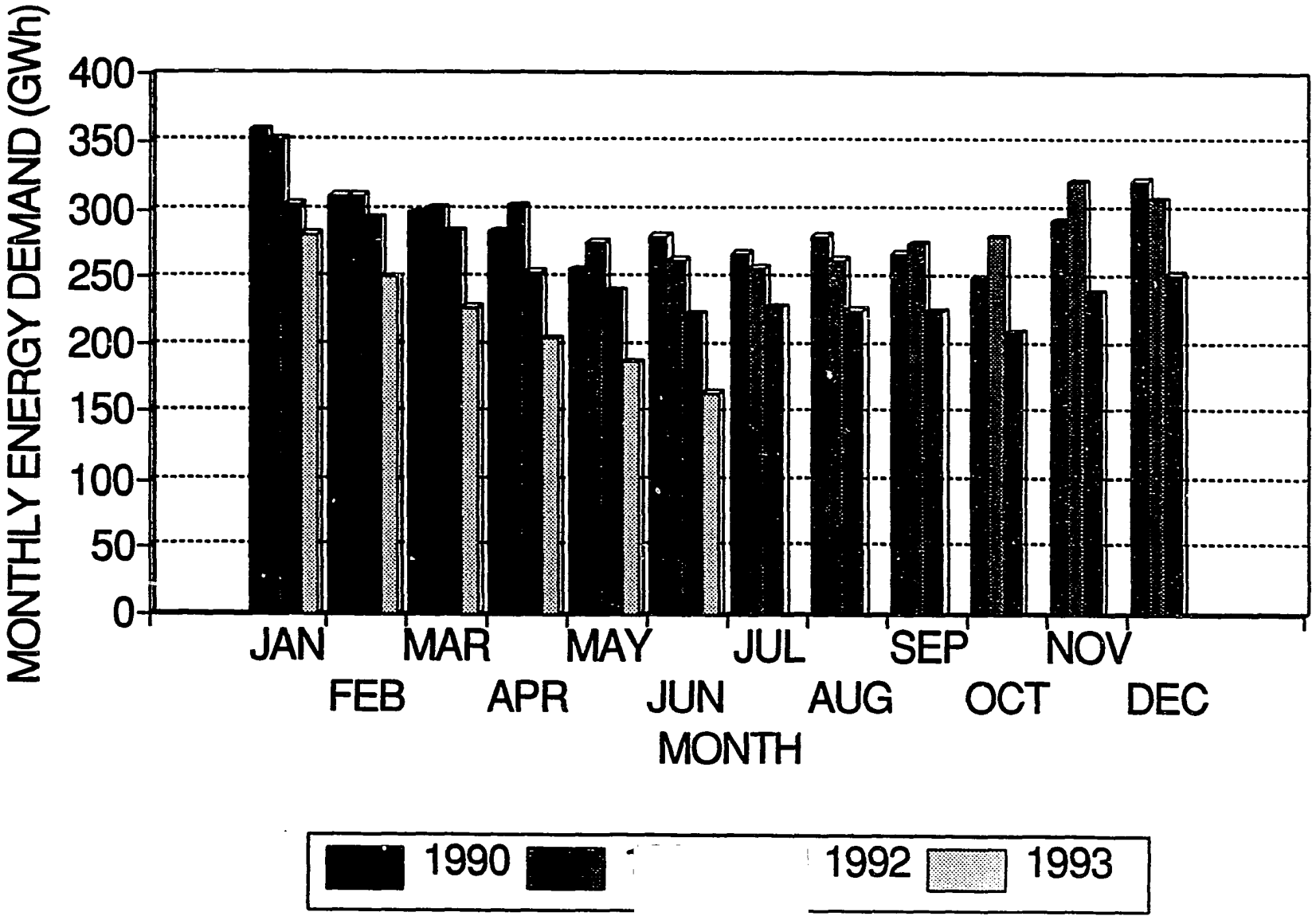
MONTHLY ENERGY DEMAND

1990-1993



MONTHLY ENERGY DEMAND

INDUSTRY



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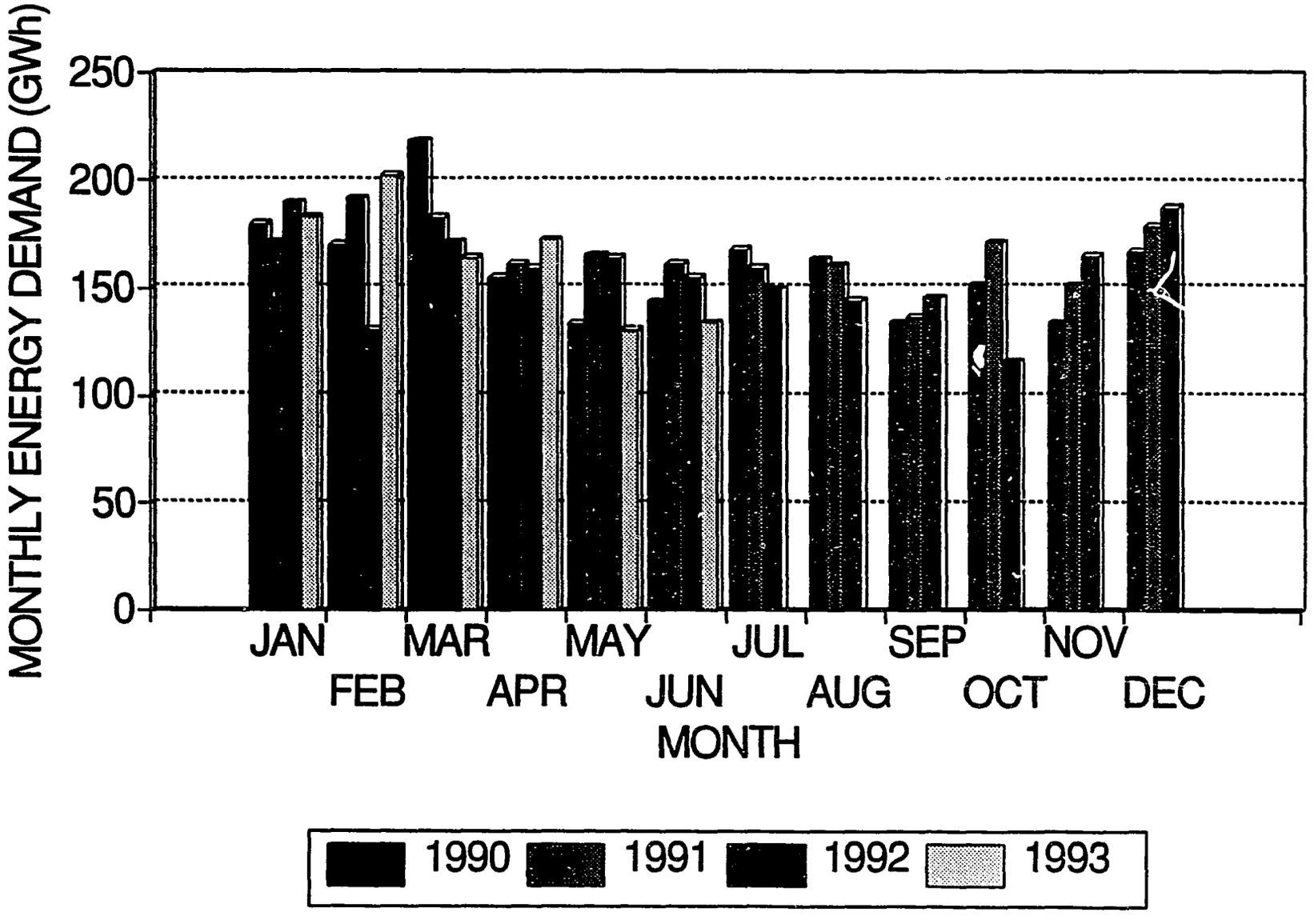
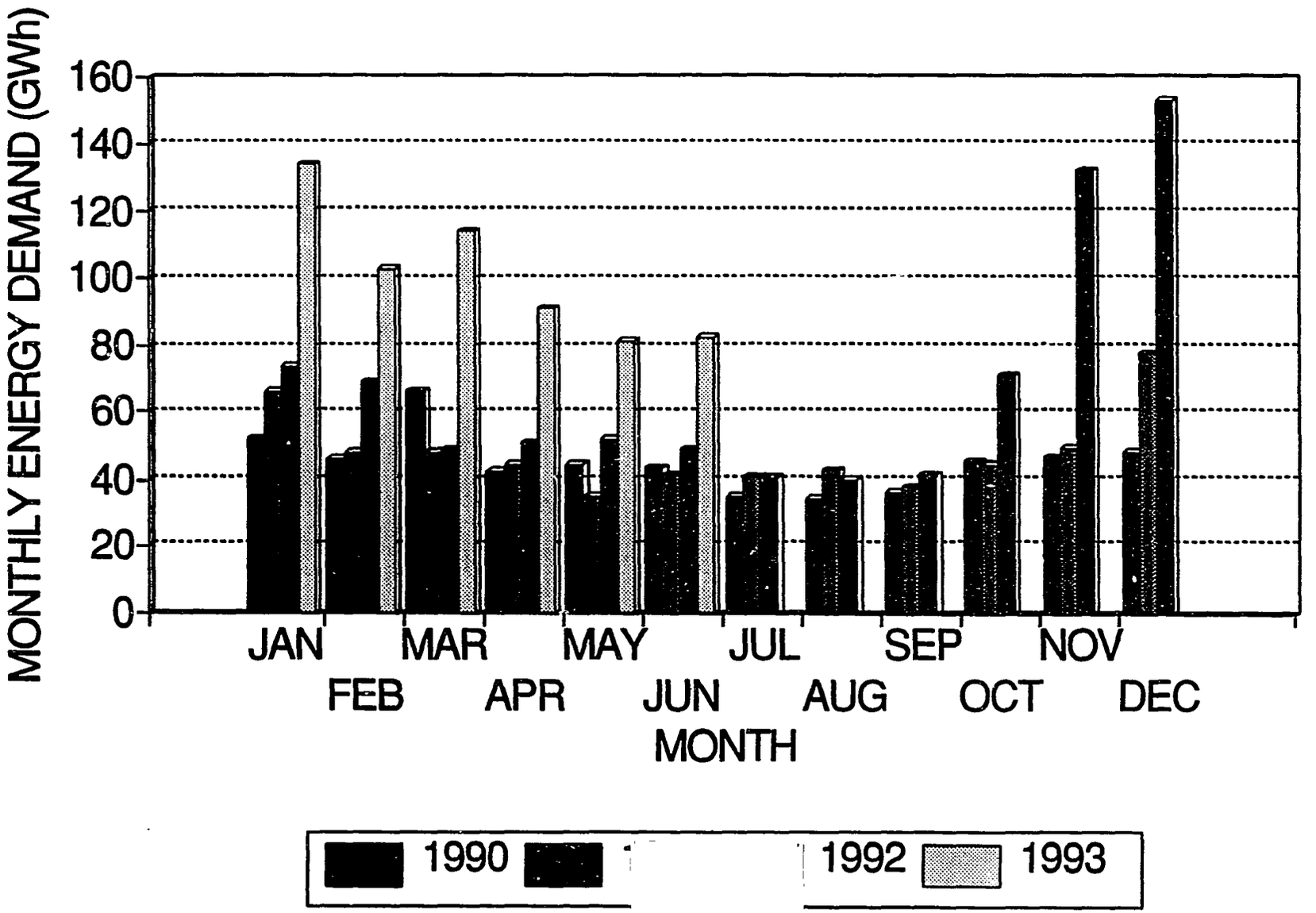
MONTHLY ENERGY DEMAND

AGRICULTURE



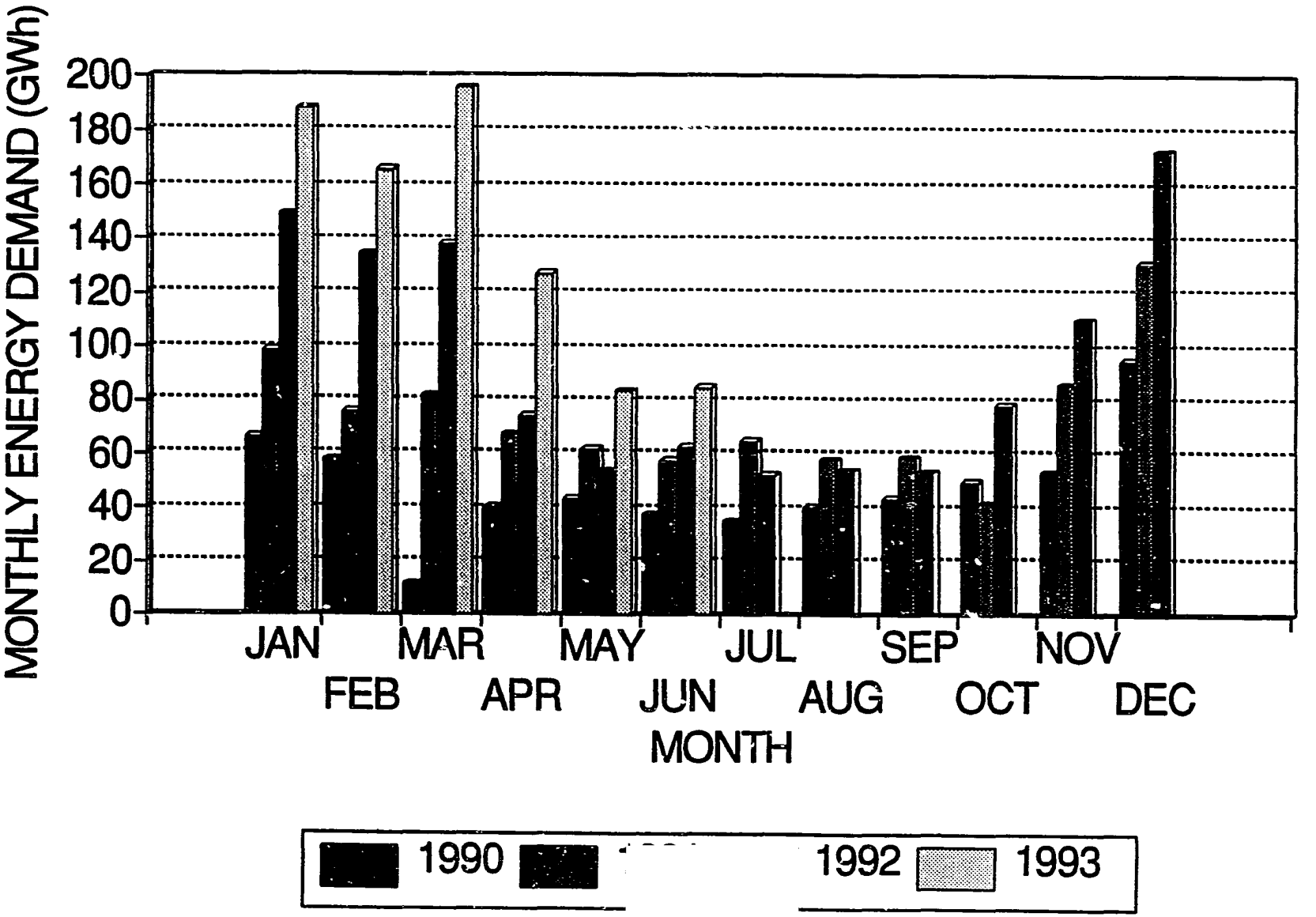
MONTHLY ENERGY DEMAND

URBAN POPULATION



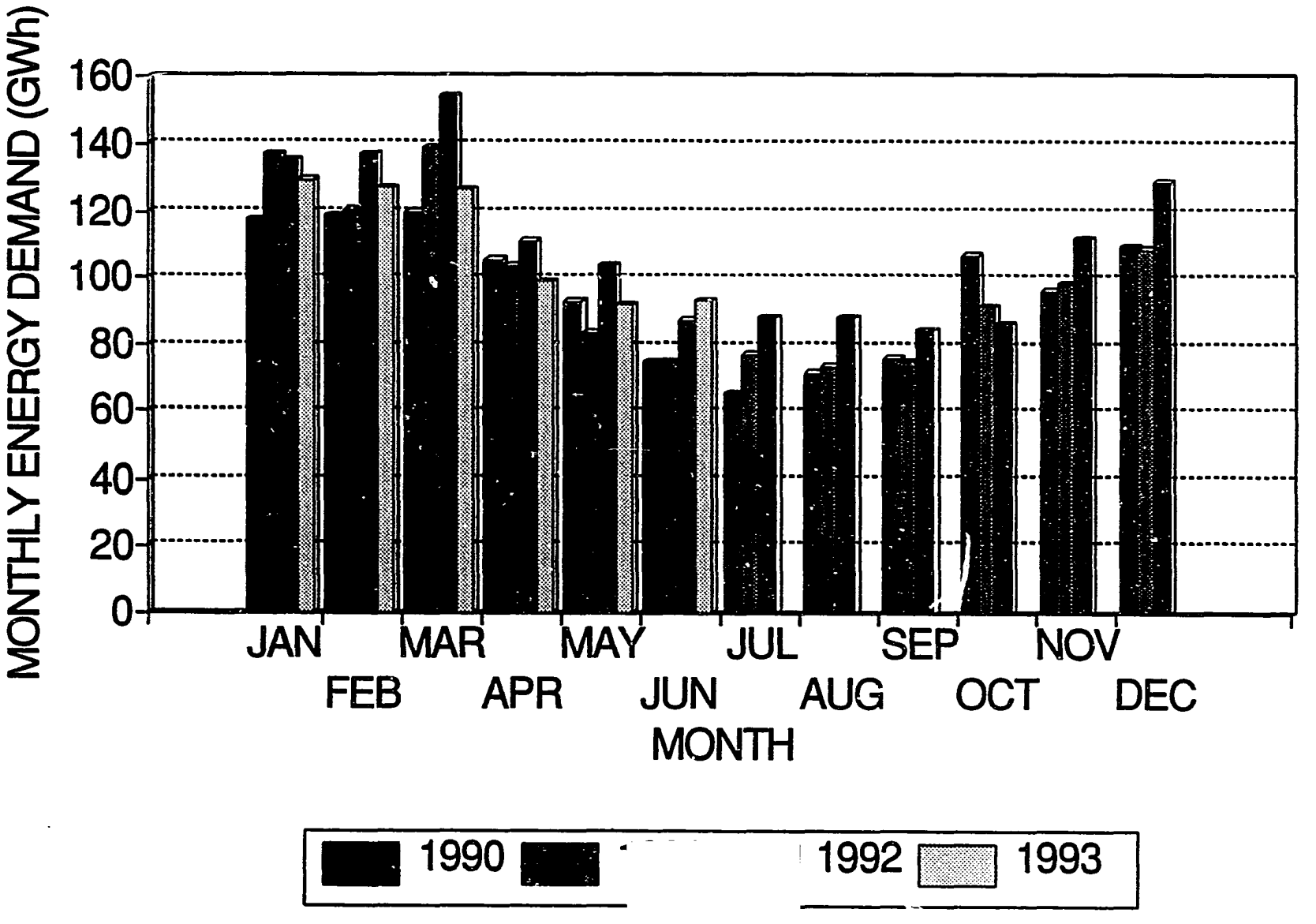
MONTHLY ENERGY DEMAND

RURAL POPULATION



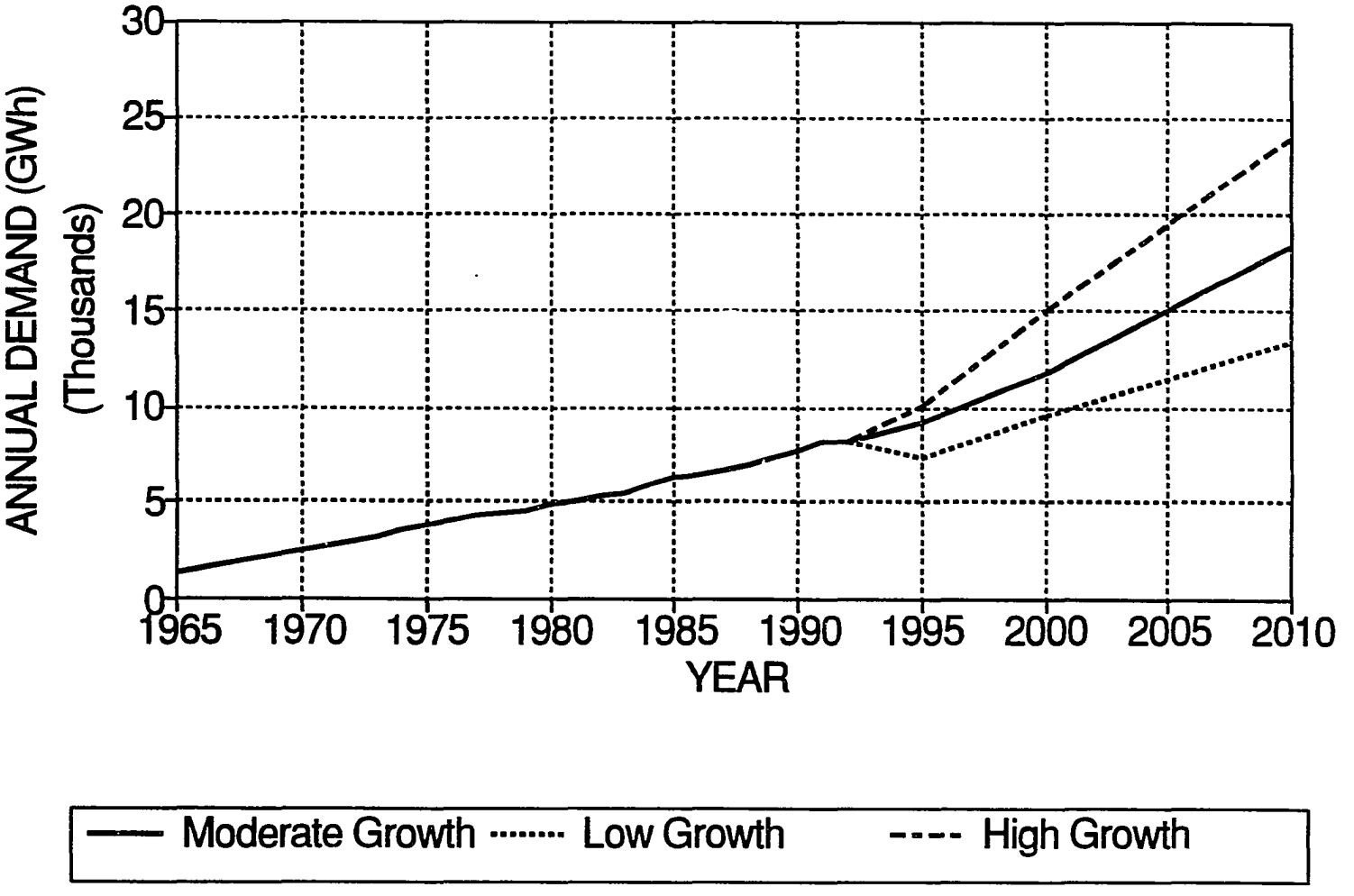
MONTHLY ENERGY DEMAND

PUBLIC SECTOR



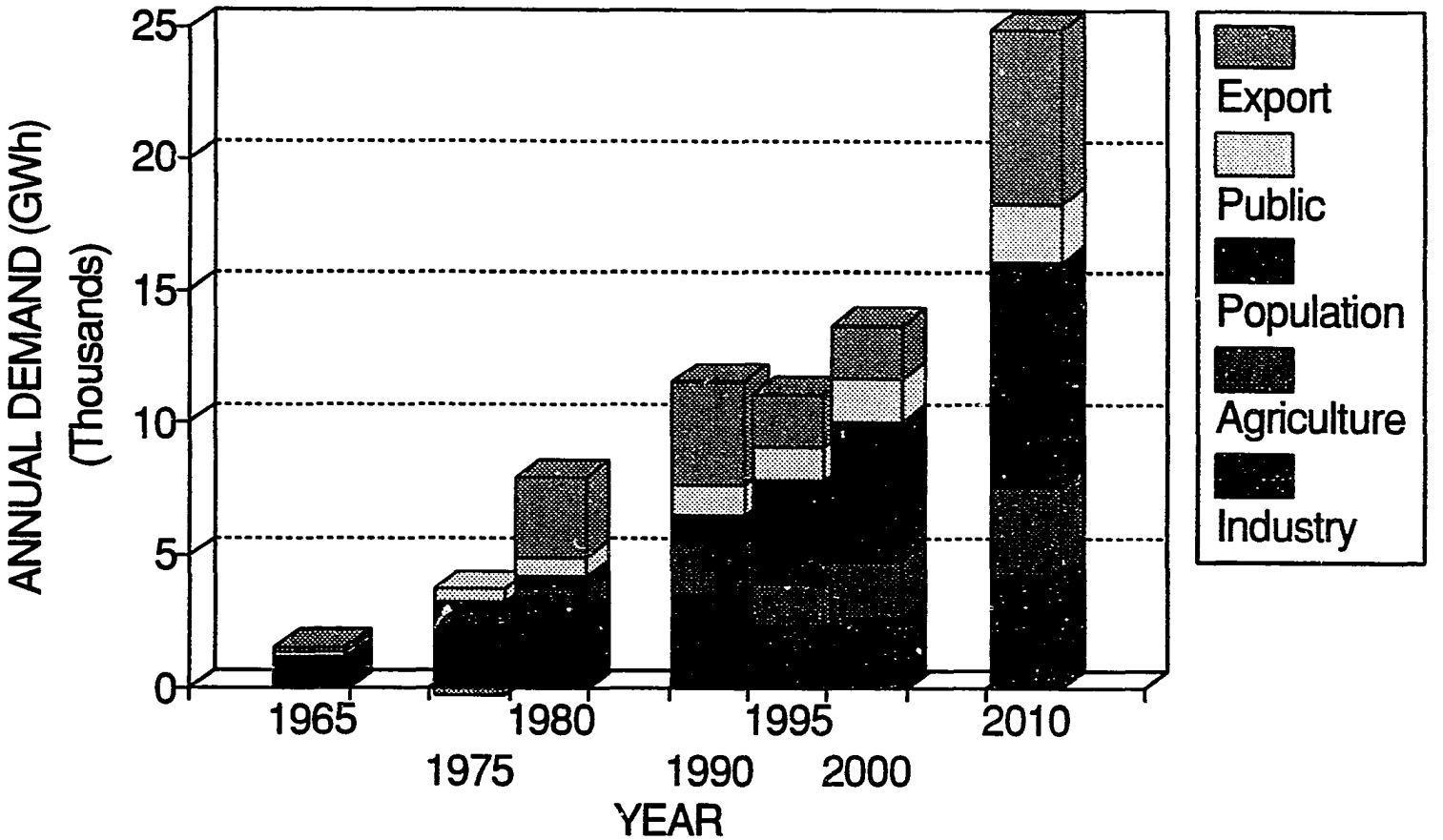
HISTORICAL AND FUTURE DEMAND

KYRGYZSTAN ONLY



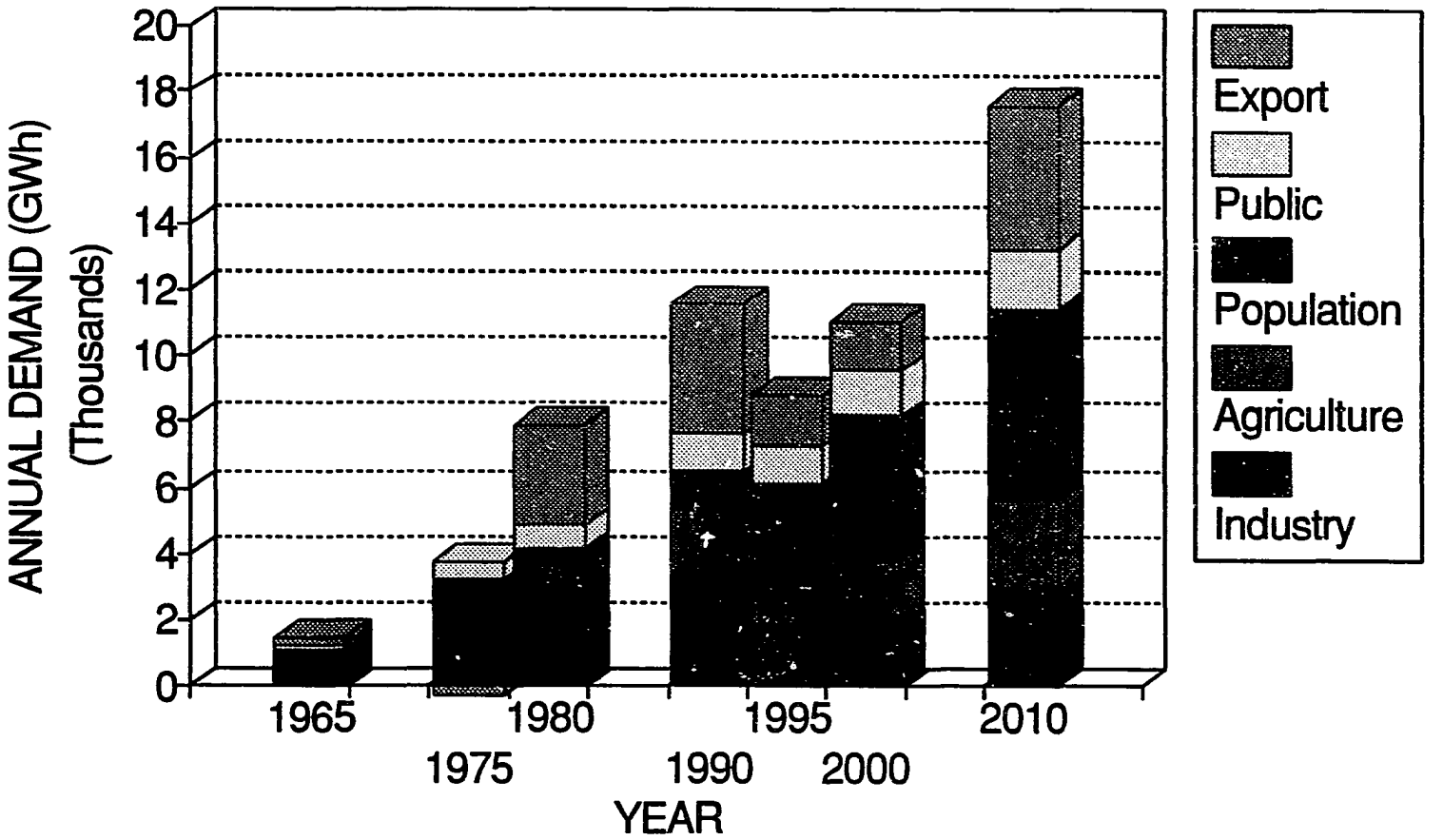
HISTORICAL AND FUTURE DEMAND

MODERATE GROWTH SCENARIO



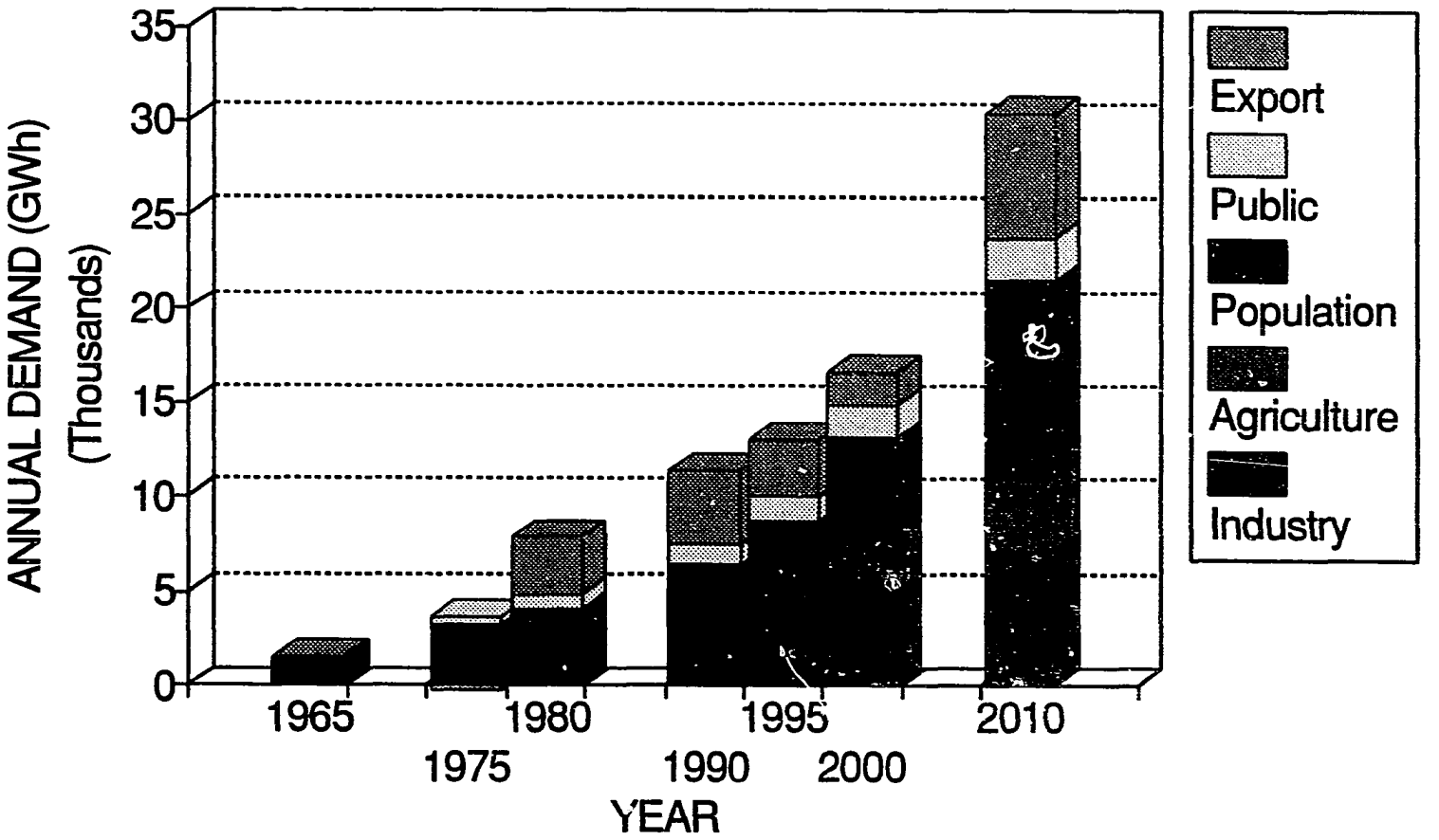
HISTORICAL AND FUTURE DEMAND

LOW GROWTH SCENARIO



HISTORICAL AND FUTURE DEMAND

HIGH GROWTH SCENARIO



HISTORICAL AND FUTURE DEMAND

KYRGYZSTAN DEMAND WITH EXPORTS

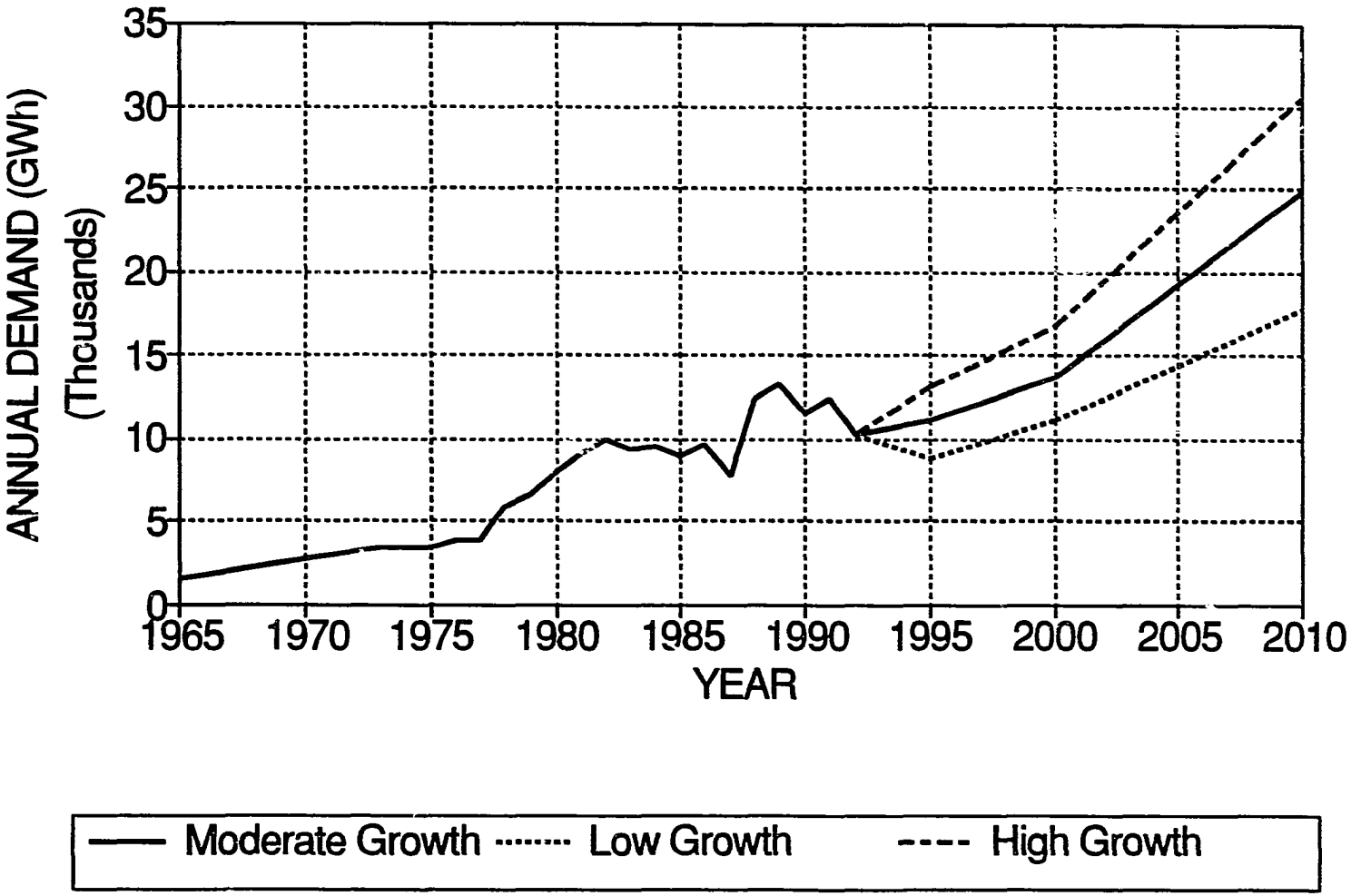
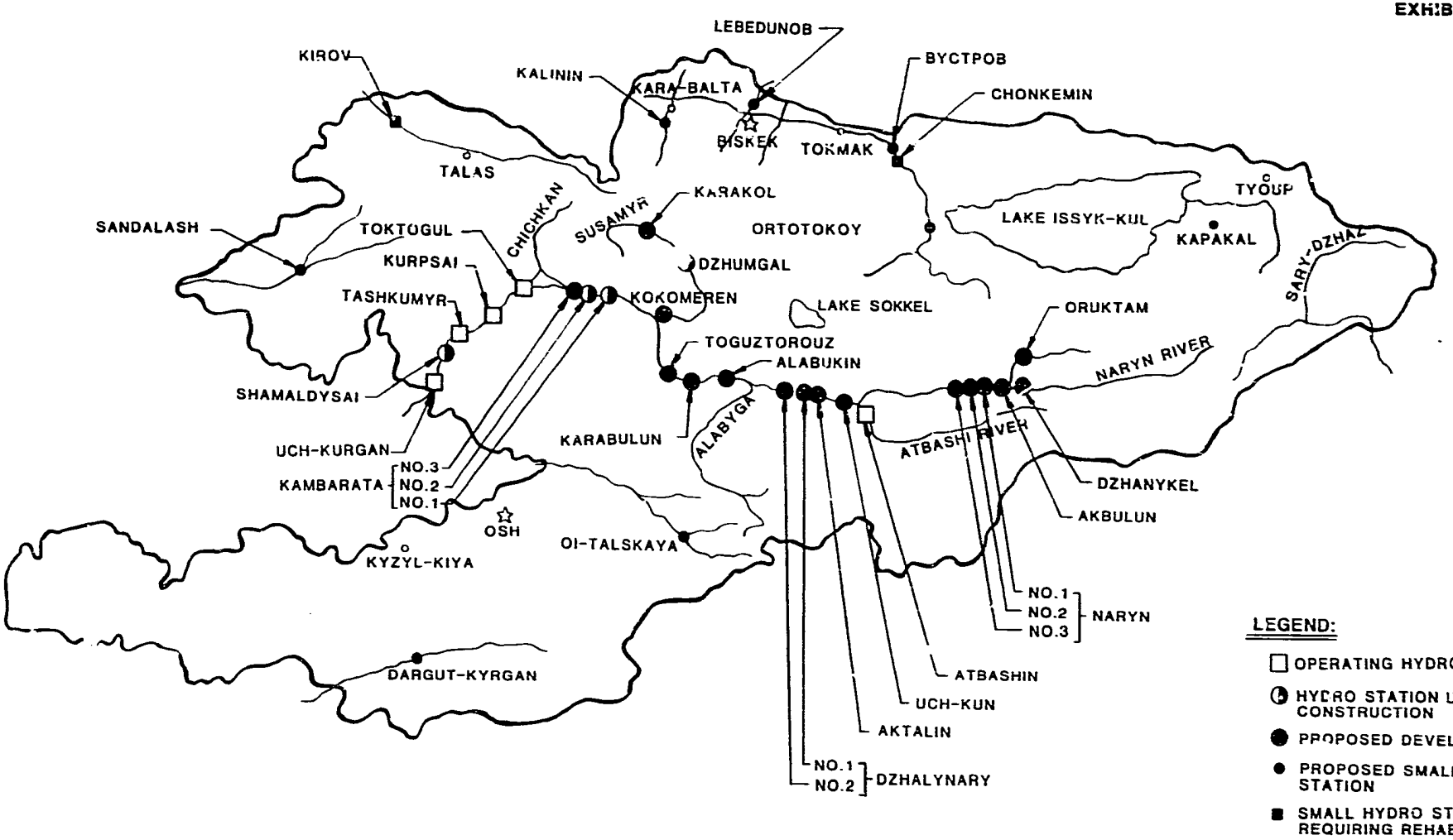


EXHIBIT 3-1



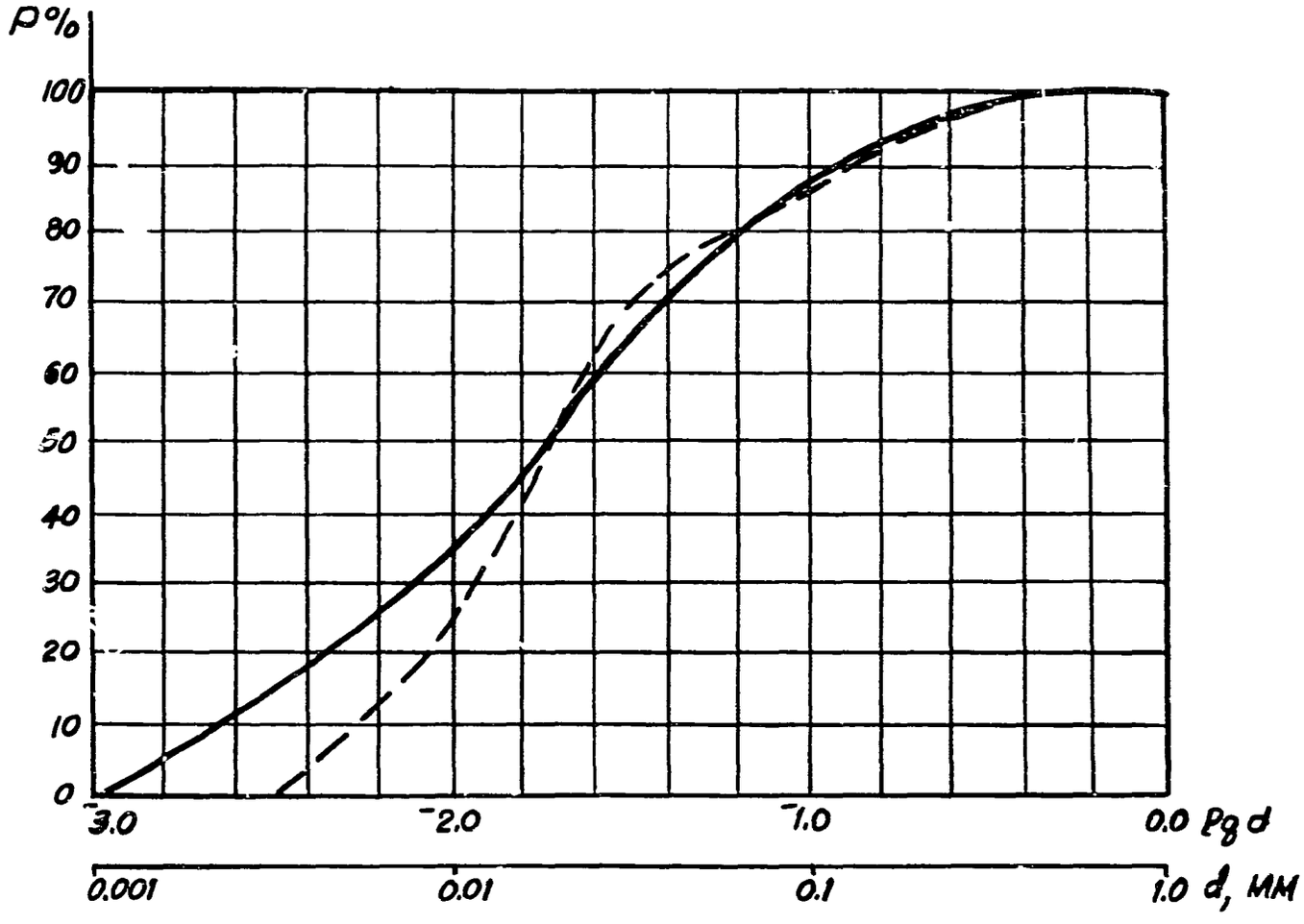
REPUBLIC OF KYRGYZSTAN

LOCATION OF EXISTING & PROPOSED HYDRO POWER DEVELOPMENTS BY 2010

HARZA ENGINEERING COMPANY

APPROVED

DATE | DWG NO



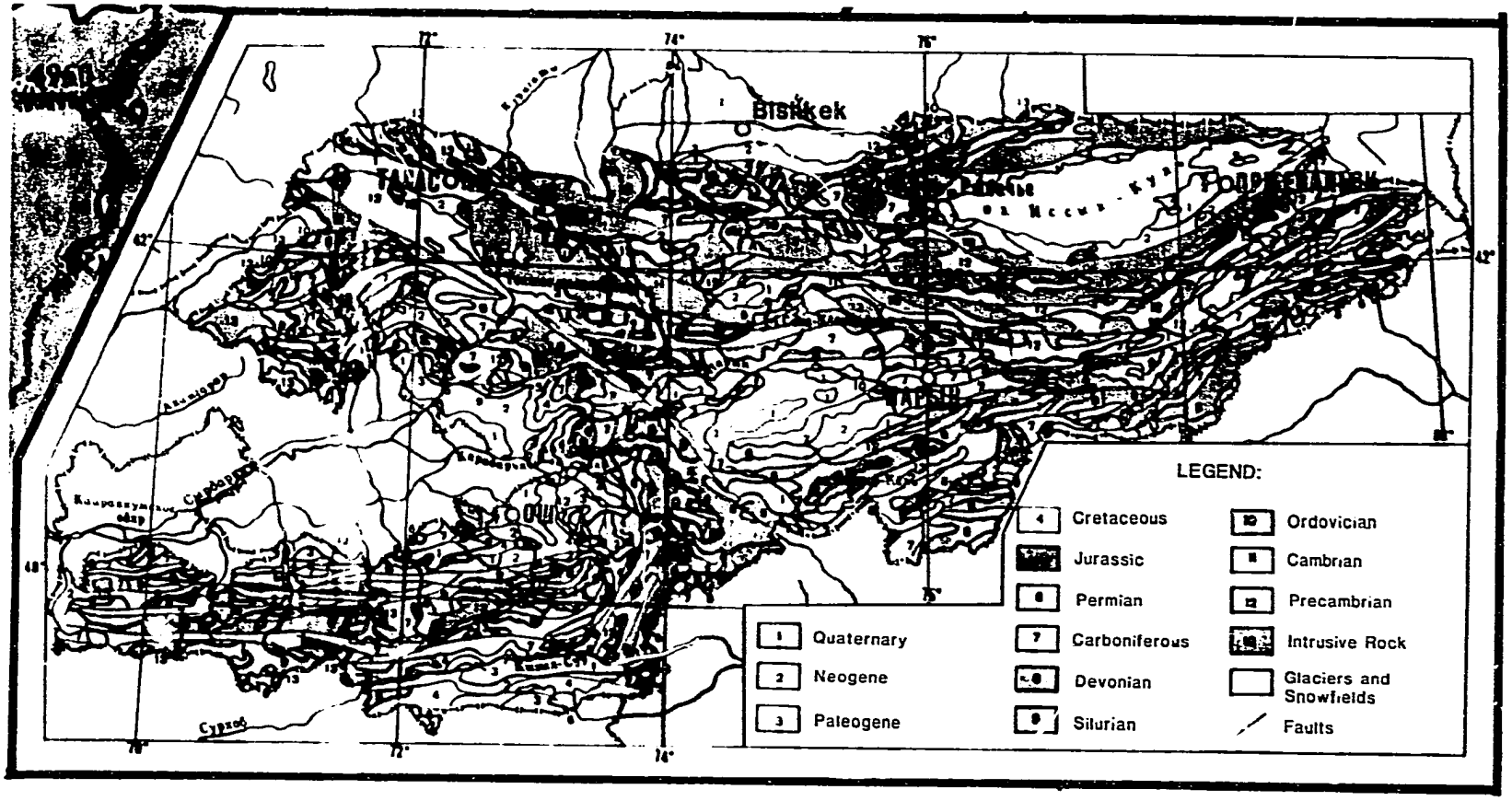
SUSPENDED SEDIMENT GRADATION CURVE

——— KAMBARATA No. 1

— — — NARYN No. 1

EXHIBIT 3-2

EXHIBIT 3-



SCALE 0 30 60 120

KYRGYZSTAN

GEOLOGICAL MAP

ARZA ENGINEERING COMPANY, AUGUST 1993

DWG. NO.

AUGUST

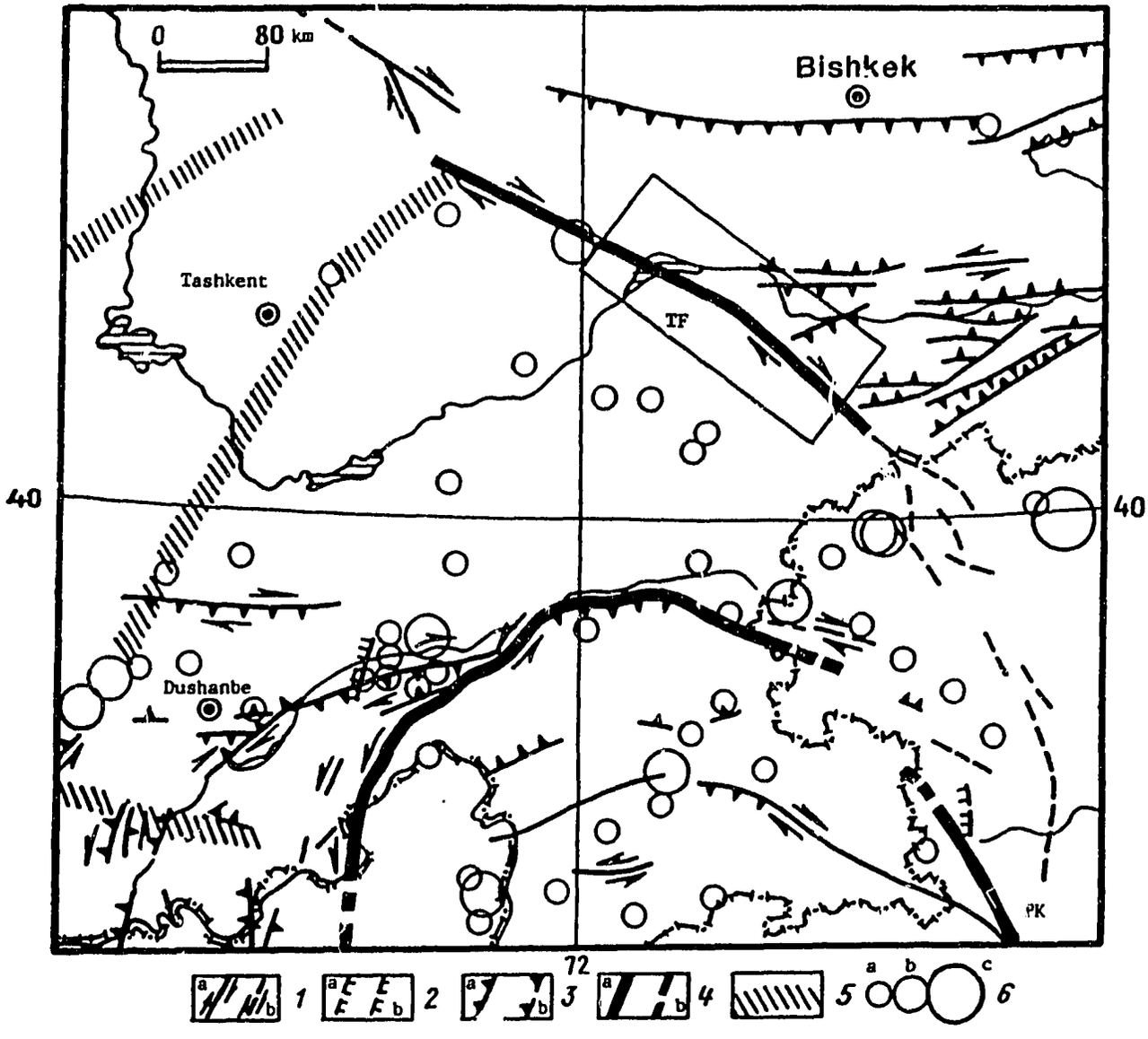


Fig. 1. Map of active faults of Central Asia [4].

1–4) Faults active in the Holocene and end of the Pleistocene confirmed (a) and inferred (b): *1*) strike-slip faults, *2*) normal faults, *3*) overthrusts and reverse faults, *4*) faults with unestablished direction of displacements; *5*) active linear zones of deep dislocations; *6*) earthquakes (1900–1976) with magnitudes of $6 \le M \le 7$ (a), $7 \le M \le 8$ (b), $M \ge 8$ (c). Faults: TF) Talaso-Fergana, PK) Pamir-Karakorum. The rectangular contour corresponds to Figs. 2 and

Chapter 3

THE NARYN RIVER SYSTEM

3.1 Topography and River System

The Naryn River is formed at the confluence of the two tributary branches: the Big Naryn River and the Little Naryn River. The source of the river is the glaciers and snowfields of the Akshiirak range. The Naryn River flows through most of Kyrgyzstan from the eastern part to the western part of the Republic, it has a length of over 800 kilometers and drops 3,000 meters ending in the Fergana Valley of Uzbekistan at elevation 500 meters. In the Fergana Valley, the Naryn River joins the Kara Daria River to form the Syr Daria River. The average watershed area is at an elevation of 3,770 meters.

The Naryn River flows through narrow canyons downstream of the Alabuga tributary and upstream of the confluence of the Kokomeren tributary. The Naryn River has a broad profile along the Naryn, Toguz Torou and the Ketmentube Hollows.

The Naryn River System is made up of five primary cascades: 1) the Upper Naryn Cascade; 2) the Kulanak Cascade; 3) the Kazarman Cascade; 4) the Kambarata Cascade; and 5) the Lower Naryn Cascade. In addition, potential hydro sites may be found along the Atbashin and the Kokomeren tributaries (see Exhibit 3-1).

3.2 Hydro-Meteorology

3.2.1 Climate

Climatic conditions are observed at the Kara Kol (elevation 3080 meters) and the Naryn (elevation 2039 meters) Meteorological Stations.

The Naryn River basin climate is mainly continental and severe. The altitudinal diversity (from 500 to 5000 meters high) accounts for the diverse climatic zones which range from moderate to glacial. The average monthly temperatures at Toktogul and Upper Naryn are summarized below on Table 3-1 and Table 3-2.

Table 3-1

Toktogul Average Monthly Climate Data

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
Air Temp.	-15.2	-10.2	2.0	12.4	18.3	21.3	24.5	24.6	19.9	11.4	3.4	-5.5	8.9
Max. Temp.	5	15	28	33	38	40	41	42	38	34	22	15	42
Min. Temp.	-38	-35	-28	-5	-1	2	6	6	1	-14	-19	-40	-40
Rainfall mm/month	24	27	39	36	45	42	25	12	5	17	29	33	334
Absolute Humidity	1.8	2.9	5.4	8.6	11.7	13.3	14.3	12.7	8.8	6.8	5.0	3.2	7.9
Relative Humidity %	82	85	78	60	58	56	52	48	45	59	73	82	65
Wind Velocity (m/s)	0.2	0.4	0.7	1.0	1.1	1.0	1.2	1.0	1.0	0.7	0.4	0.2	0.7

Table 3-2

Upper Naryn Average Monthly Climate Data

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
Air Temp.	-17.1	-13.8	-4.1	6.7	11.6	14.5	17.2	17.0	12.4	5.4	-4.3	-13.2	2.8
Rainfall mm/month	12	13	21	32	55	52	41	22	17	14	13	11	303
Relative Humidity %	78	77	70	54	53	54	49	45	43	49	64	75	59
Wind Velocity (m/s)	1.2	1.4	1.6	2.1	2.2	2.4	2.5	2.4	2.3	1.9	1.4	1.2	1.9

The Naryn basin climate is typically dry. The minimum winter temperatures for January and February are mainly observed in mountain valleys in which cold air remains confined: Ketmentube hollow -40°; Susamyr Valley -51°; and Arca and Aksai valleys in the southern

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part of the country, -50° to -55°. The maximum summer temperature of 42° for late July and early August are observed in the Ketmentube Hollow. Upstream of the Ketmentube Hollow at an altitude of 3000 meters the maximum summer temperature is only 21°.

The non-frost period lasts 146 days at the location of the proposed Naryn No. 1 Hydroelectric Station.

3.2.2 Available Hydrometeorological Data

Eleven meteorological stations and twenty-six meteorological observation points are located in the Naryn River basin at altitudes ranging from 802 meters at the Ketmentube Meteorological Observation Station to 3614 meters at the Tien Shan Meteorological Stations (Tashkent, Report No. 1283-T5).

Rainfall in the Naryn River basin is low and irregularly distributed both by area and season. Rainfall is higher on the northern and western slopes and lower on the southern and eastern slopes. The maximum annual rainfall of 417 mm was observed at both the Ikki Naryn meteorological station, at the Big and Little Naryn River confluence, and the Ketmentube meteorological station. The minimum annual rainfall of 236 mm was registered at the Kara Kul meteorological station and in the Alabuga River midstream (Tashkent, Report 1283-T5).

3.2.3 Sediment Data

The average annual suspended sediment yield at the Kambarata site equals 13.9 million tons (440 kilograms per second). About 94 percent of the total annual suspended sediment is transported downstream during the period April to August. The average annual bedload yield is 0.97 million tons.

The average annual water density at Kambarata varies from 0.39 to 1.4 kilograms per m^3 (Tashkent, 1283-T5). Suspended sediment gradation curves for the locations, Kambarata No. 1 and Naryn No. 1, are shown on Exhibit 3-2.

During the June 1993 site visit, Harza observed that the Little Naryn River is brownish in color due to suspended sediment, whereas the Big Naryn is gray colored. The suspended sediment mixes with the flow downstream of the confluence of the two rivers.

Most of the Naryn River suspended sediment settles to form a delta in the Toktogul Reservoir. Water discharged from Toktogul is clear and blue in color. Suspended sediment was observed being added to the Naryn River from tributaries downstream of Toktogul.

3.3 Streamflow

The Naryn river basin has a drainage area of 58,370 km^2 (Tashkent, Report No. 1389-T3). The average multi-annual flow of the Naryn at the Kambarata No. 2 site is 317 m^3/s for the period of record from 1910/11 to 1986/87. The maximum discharge results from snow melt. Low flow discharges are only from groundwater storage.

The Naryn River flow begins to increase in April and reaches a peak in May-June. The flow subsides in September-October and achieves a minimum in December-January. At the Kambarata site, the maximum measured water flow at Ugh Terek varied from 652 m^3/s in 1974 to 2400 m^3/s in 1966.

Average monthly and yearly flow data is included below on Table 3-3.

Table 3-3

Average Naryn River Flow Data

Monthly Flow (m^3/s)	Kambarata No. 1	Naryn No. 1	Naryn No. 2	Akbulun	Dzhanykel	Oruktam
January	123	20	24.2	19.8	11.8	8.0
February	124	19.6	23.7	19.3	11.5	7.8
March	140	21	25.3	20.8	12.6	8.2
April	219	40.7	44.9	41.1	22.2	18.8
May	478	99.4	109.3	98.7	52.4	46.3
June	776	170	190.9	170	86.7	83.1
July	686	194	218.7	194.8	99.0	95.8
August	514	164	180.2	164.1	83.8	80.2
September	275	74.8	81.7	74.3	38.1	36.1
October	184	38.4	42.6	38.1	20.4	17.8
November	156	27.8	31.7	27.6	15.5	12.0
December	133	22.3	26.5	22.2	12.8	9.4
Yearly Average (m^3/s)	317	74.4	83.3	74.2	38.9	35.3

Average monthly flow at Naryn No. 3 is approximately equal to Naryn No. 2.

The Naryn River flow during the summer months is much greater than during the winter months. The average flow at Kambarata No. 1 for the period April through September is 491 m^3/s. The average flow for the period October through March is 143 m^3/s.

3.4 Geology and Seismicity

Geological and geotechnical investigations studies were conducted by the Tashkent Design Institute. The major components of the investigation program for each of the proposed hydroelectric stations included:

- Initial site visits and assessments;
- Geologic mapping of project sites;
- Subsurface investigations for project structures and sources of construction materials;
- Laboratory testing of soil and rock samples;
- Detailed analysis of investigation findings and results;
- Development of design criteria; and
- Geophysical exploration.

Harza conducted a review of the geological and geotechnical investigation studies and conducted a review of regional geologic data. Harza's review included the following components:

- Office review of existing maps;
- Review of report and article descriptions;
- Review of design criteria;
- Literature search and review of regional geologic data; and
- Project site reconnaissance survey.

These technical components of the geologic and geotechnical investigations, and a description of the overall country geology are discussed in the following sections of this chapter on "The Naryn River System"; detailed discussion of project site engineering geology are included in the specific hydroelectric project chapters V, VI, and VII.

3.4.1 Regional Geologic Setting

Kyrgyzstan is situated at the juncture of the two largest folded belts of Eurasia: Urals-Mongolian and Alpine-Himalayan. The Tien Shan mountains of Kyrgyzstan are the southern margin of the Urals-Mongolian folded belt. The Pamirs, located in the southern-most part of Kyrgyzstan, are the northern margin of the Alpine-Himalayan. The main structural features of the region are due to southward displacement of the Urals-Mongolian

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belt and the northward movement of the Alpine-Himalayan belt. The European-Tarim platform is overlapped on the territory of Kyrgyzstan.

A geologic map of Kyrgyzstan is shown on Exhibit 3-3.

Kyrgyzstan is characterized by a long, multistaged geologic history. Geologic bodies are found from all periods from the Archean almost continually to the Quaternary. Deposition, intrusive magmatism, tectonic deformations and metamorphism of rocks occurred in four megastages:

1. Archean protogeosynclinal-orogenic;
2. Proterozoic platform-orogenic;
3. Late Proterozoic-Paleozoic geosynclinally-orogenic; and
4. Mesozoic-Cenozoic platform-orogenic.

Each of the four episodes includes the period of time during which the cyclic change of the direction of the Earth's crust movements took place. During each megastage, a period of deposition was followed by mountain building processes.

From the Cambrian period to the middle Carboniferous, Kyrgyzstan was partly covered with the waters of the Turkestan paleoocean. The Turkestan basin extended from the Aral Sea through Fergana to Kyrgyzstan. The northern margin of the Turkestan paleoocean was likely a subduction zone causing eruptions of andesite lavas during the Silurian and Devonian periods.[1] The andesititic volcanism was followed by acidic volcanism. The Turkestan paleoocean appears to have closed by the middle Carboniferous and the process of the collision of the Kyrgyz and the European-Tarim continents began.

The Precambrian deposits are situated along the Naryn in the form of granite and other intrusive rocks. Metamorphic rocks are finely crystalline and schistose, with interlayered fine-granular meta-sandstones. Sequences are 400-500 meters thick. PreCambrian amphibolite (100 meters thick) is fine granular and amorphous, biotite, chlorite and scarn. Marble limestones 500 to 700 meters thick with some breccia.

Ordovician rocks (Nikitin, 1986, p. 2) in Kyrgyzstan consists mainly of geosynclinal marine terrigenous clastic sediments with rare volcanics. Most Ordovician faunal groups are found including: radiolaria, sponges, echinoderms, bryozoa, brachiopods, ostracodes, mollusc, corals, trilobites, graptolites, conodonts, and algae. The rocks are unevenly interlayered sandstones and siltstone, with some limestones. Some tuffs and conglomerates are found

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[1]Bakirov, 1984, p. 19, evidence for subduction and andesite eruption is evidenced by glaucophane-shale metamorphism of rocks in the marginal part of the ocean in the Silurian.

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in the middle and upper part of the series. The total thickness is about 3000 meters.

Silurian and Devonian rocks include massive limestones, reef limestones, and some cherts (Leonov, 1985, p. 387). Marine and shallow marine depositional environments prevailed. Shales were also deposited during the Silurian. The late Devonian also included deposition of terrigenous siltstone and sandstone and andesite rocks.

The Turkestan ocean closed during the Carboniferous. The subduction of the oceanic crust on the ocean northern margin resulted in rapid closure of the oceanic structure. positional environment was variable in Kyrgyzstan. In the Southern Tien Shan area, the deposition of limestones continued into the Lower Carboniferous period. The abutment rock at Toktogul is massive Carboniferous limestone. Elsewhere, siltstone, shale, conglomerates, sandstones and gypsum was deposited.

As continental crust converged, a series of overthrusts were created. The existing mountain ranges in Kyrgyzstan were formed by the combination of overthrusts, volcanism and intrusive activity. The overthrusted crust originally slid onto the shelf of the European-Tarim continent.

Most rocks deposited after the Carboniferous were deposited in terrestrial and fluvial environments. During the Permian Period, red conglomerates and sandstones were deposited along with marls and tuffs. Some Permian limestone and gypsum was deposited in the western part of Kyrgyzstan during the final Turkestan sea regression.

Mesozoic rocks include only the Jurassic Period which includes claystone, siltstones, sandstones, and conglomerates. The thickness is 150 to 200 meters.

3.4.2 General Seismic Framework

There are numerous active faults in Kyrgyzstan (see Exhibit 3-4).

The most important active fault is the Talaso-Fergana right-slip fault. The Talaso-Fergana active right-slip fault is 500 km long. The amplitude of displacement along the fault since the beginning of the Pleistocene or the end of the Pliocene reaches 12-14 km (Trifonov, 1990, p. 443). The present rate of slip, .5-1.4 cm/yr, is not changed much since the Pleistocene, .8-1.7 cm/yr. The slip rate is greatest along the center of the fault where it is about 1.5 cm/yr to the northwest of Toktogul Reservoir (Trifonov).

On August 19, 1992, an earthquake occurred along the Talaso-Fergana fault. The epicenter, determined by the data registered by the seismic stations of Kyrgyzstan, was located at 42.04 N latitude and 73.38 E longitude, about 100 km northeast of Toktogul Hydroelectric Station. The earthquake manifested itself with a force of magnitude 9 (Soviet scale) on the mountain

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pass Muztor and with magnitude 8 felt in the remote settlements of Toluk and Sarysogot (EERI Newsletter, Nov. 1992, p. 4).

3.5 Hydropower Development on the Naryn River

Exhibit 3-1 shows the location of existing, under-construction, and proposed hydroelectric stations.

3.5.1 Existing

Previous hydropower development along the Naryn River focused on the Lower Naryn Cascade. The following Lower Naryn Cascade projects are fully operational as of June 1993:

Toktogul Hydroelectric Station;
Kurpsai Hydroelectric Station; and
Uchkurgan Hydroelectric Station.

Toktogul Hydroelectric Station is shown in Photographs 3-1 and 3-2. Kurpsai Hydroelectric Station is shown in Photographs 3-3 and 3-4.

Other hydropower development along the Naryn River includes the Atbashin Hydroelectric Station. Atbashin is located in the mid-section of the Naryn River at the confluence of the Atbashin tributary.

3.5.2 Under Construction

The following hydropower developments are under construction:

Tashkumir Hydroelectric Station;
Shamaldisai Hydroelectric Station; and
Kamabarata No. 2 Hydroelectric Station.

Construction of the Tashkumir Hydroelectric Station is nearing completion (see Photograph 3-5). The first unit began generation of 25 MW by the end of 1985. All three units have been on line from 1987 to 1992, generating 75 MW (due to cavitation governed capacity limits under limited tailwater conditions). The reservoir is planned for filling to elevation 628 meters by the end of 1994, for the generation of 450 MW. The following tasks remain:

- The dam must be raised to elevation 631.0 meter;
- Finish works at the powerhouse;

- Construct sulphur-catching diaphragms;
- Finish grouting the water intake canal;
- Finish construction and maintenance water discharge system;
- Complete the maintenance and security premises; and
- Build a bridge across the overflow spillway and place access road surfaces.

Shamaldysai Unit No. 1 was placed on line in 1992 generating 15 MW. Units 3 and 4 are planned to be on-line by the end of 1993 and 1994, respectively. The station is planned for full capacity generation (240.0 MW) by the end of 1994 with the reservoir filled to elevation 572.0 meters. Shamaldysai is shown in Photographs 3-6 and 3-7. To complete the Shamaldysai Hydroelectric Station:

- Additional earth and rock fill must be placed;
- The injected cement core must be constructed;
- Unit No. 2 must be finished;
- Unit No. 3 must be installed; and
- A bridge and highway must be constructed.

Construction of Kambarata No. 2 is about 30 to 40 percent complete. Spillway and power tunnels have been excavated. Preliminary tunnel liners have been constructed. The powerhouse foundation excavation was completed (see Photograph 3-8). The tunnel inlets are shown in Photograph 3-9.

3.5.3 Planned and Proposed

Considerable additional hydropower development has been planned and proposed:

Hydropower Development	Capacity
Upper Naryn Cascade	350 MW
Dzhanykel	
Oruktam Nos. 1,2	
Akbulun	
Naryn Nos. 1,2,3	
Kulanak Cascade	439 MW
Ugh-Kun	
Aktalin	
Dzhalynar Nos. 1,2	
Kazarman Cascade	900 MW
Alabugin	
Karabulun	
Toguztorouz	

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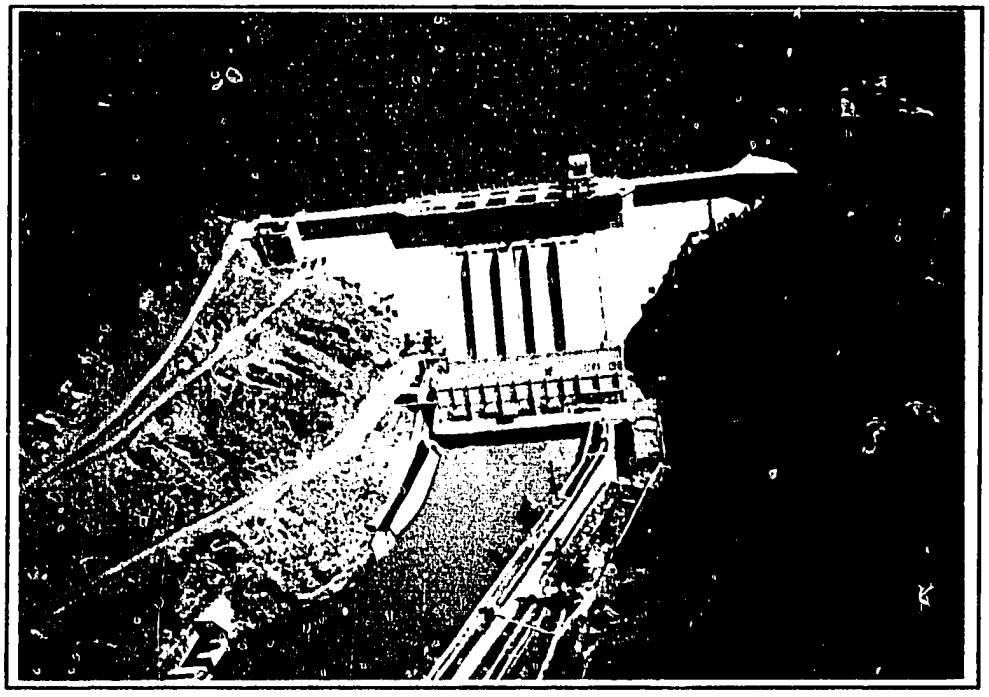
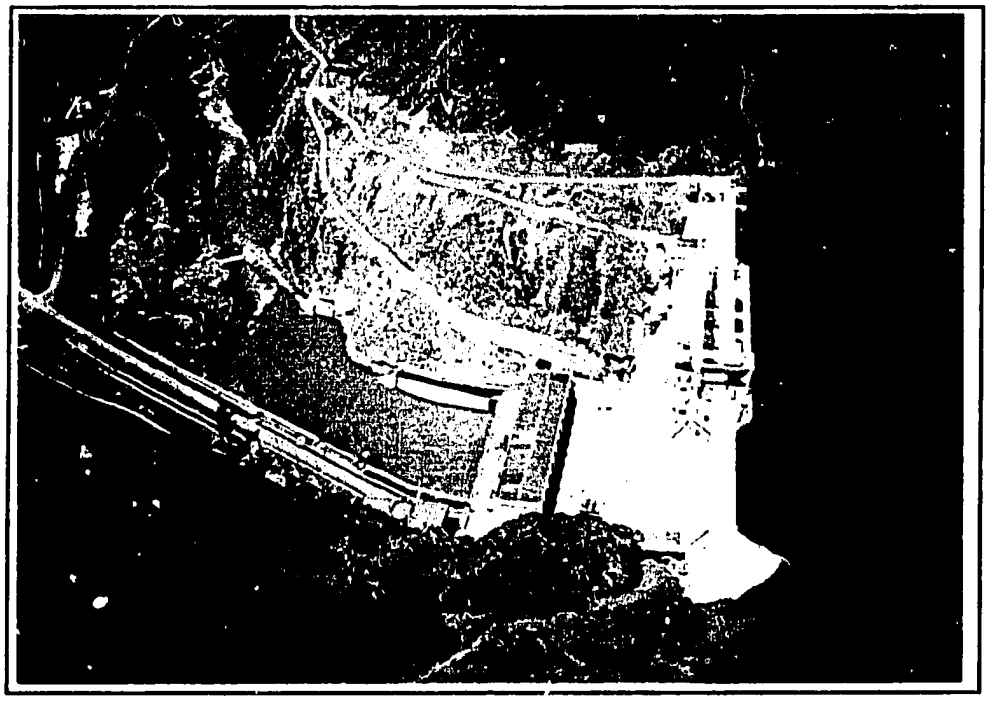
Kokomeren Tributary	1,305 MW
Karakol	
Dzhumgal	
Kokomeren	
Kambarata Cascade	2,430 MW
Kambarata Nos. 1,2,3	

Photograph 3-1 - Toktogul Hydroelectric Station

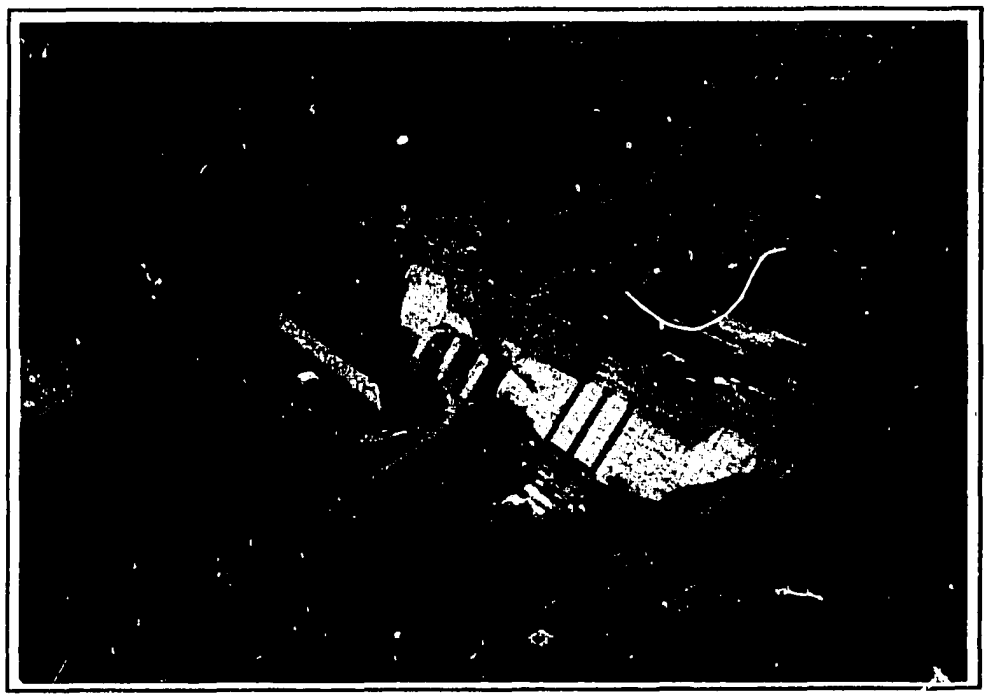
Photograph 3-2 - Toktogul spillway chutes



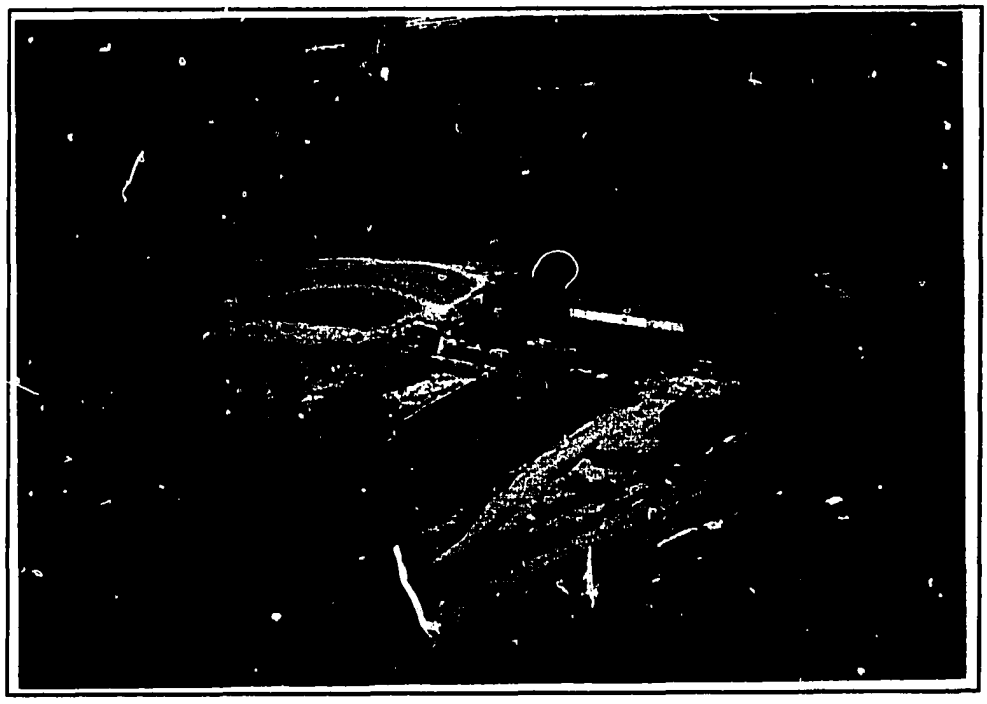
Photograph 3-3 - Kurpsai Hydroelectric Station



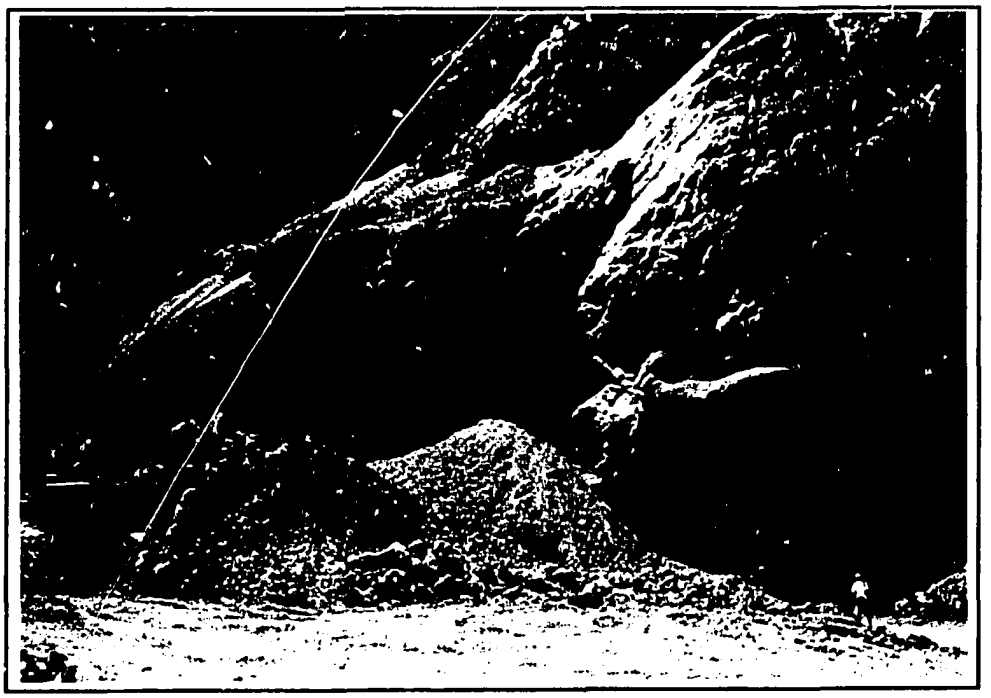
Photograph 3-4 - Kurpsai Hydroelectric Station



Photograph 3-5 - Tashkumir Hydroelectric Station



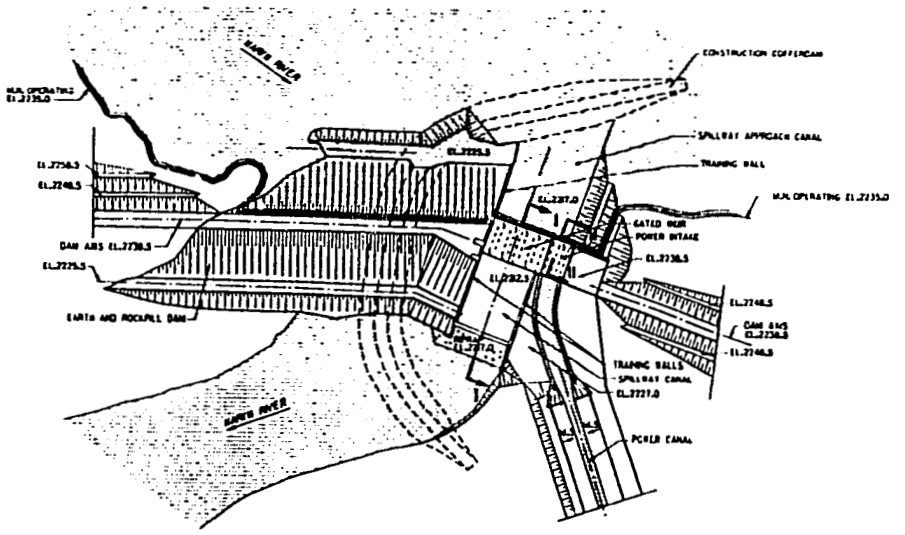
Photograph 3-6 - Shamaldisai Hydroelectric Station



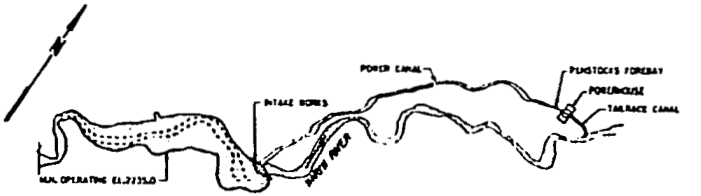
Photograph 3-9 - Kambarata No. 2 Hydroelectric Station spillway and power tunnel inlets

Photograph 3-7 - Shamaldisai Hydroelectric Station

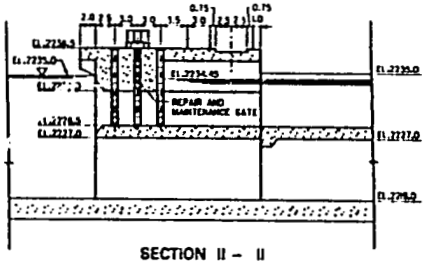
Photograph 3-8 - Kambarata No. 2 Hydroelectric Station powerhouse foundation excavation



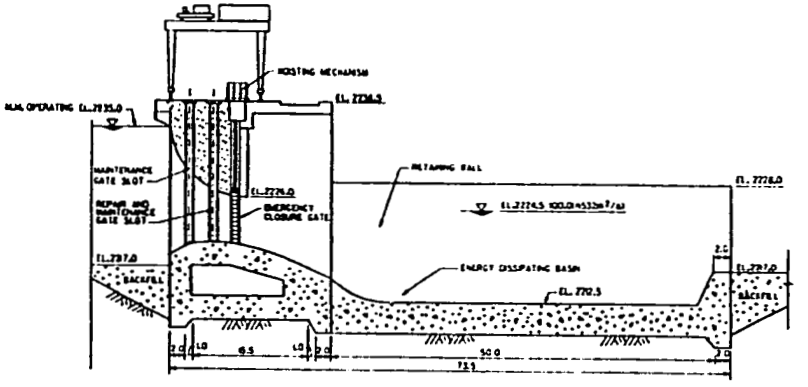
PLAN VIEW
POWER INTAKE AND WEIR WORKS
SCALE 0 25 METERS



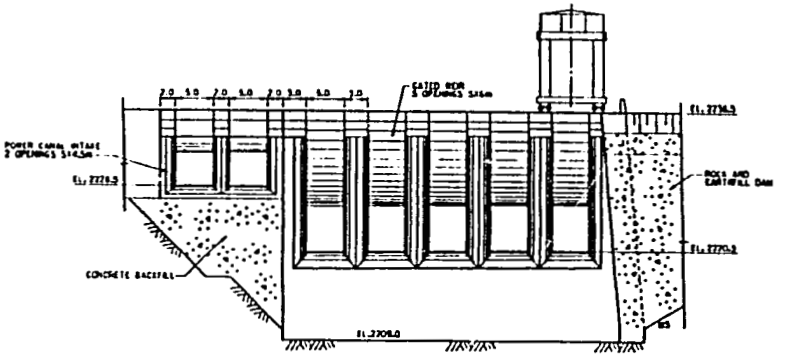
GENERAL ARRANGEMENT
SCALE 0 500 METERS



SECTION II – II
POWER INTAKE
SCALE 0 5 METERS



SECTION I – I
GATED WEIR
SCALE 0 5 METERS



UPSTREAM ELEVATION
INTAKE AND WEIR
SCALE 0 5 METERS

NOTE:
BASED ON THE TASHKENT HYDRO DESIGN INSTITUTE (THDI) LAYOUTS.

ARZA ENGINEERING COMPANY AUGUST 1993

KYRGYZSTAN
NARYN 1 POWER PLANT

INTAKE – PLAN VIEW
AND SECTIONS

DWG. NO. UN-01 AUGUST 1993

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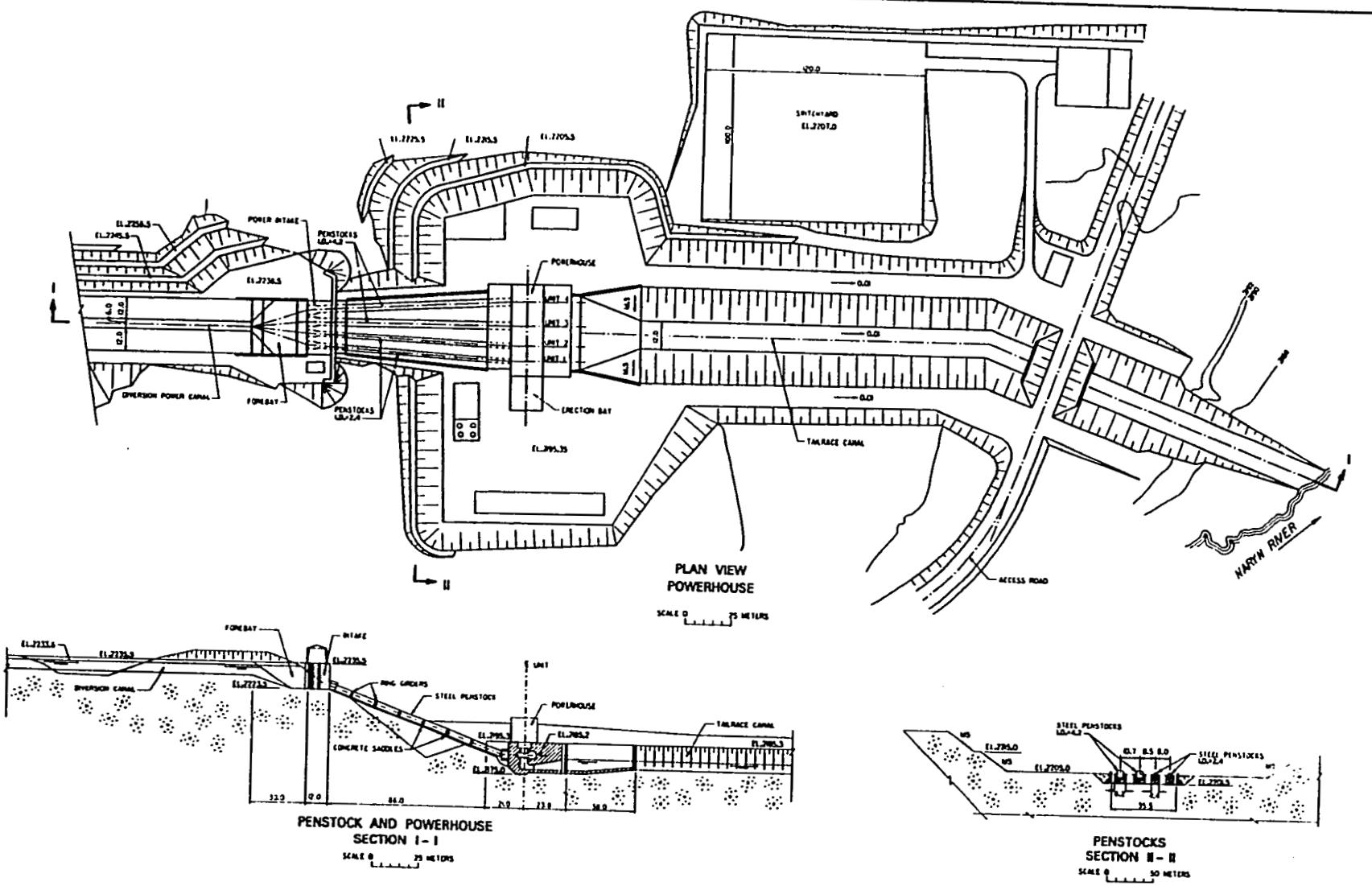

NOTE:
BASED ON THE TASHKENT HYDRO DESIGN INSTITUTE (THDI) LAYOUTS.

ARZA ENGINEERING COMPANY AUGUST 1993

KYRGYZSTAN
NARYN 1 POWERPLANT

GENERAL ARRANGEMENT
PLAN VIEW AND SECTIONS

DWG. NO. UN-02 AUGUST

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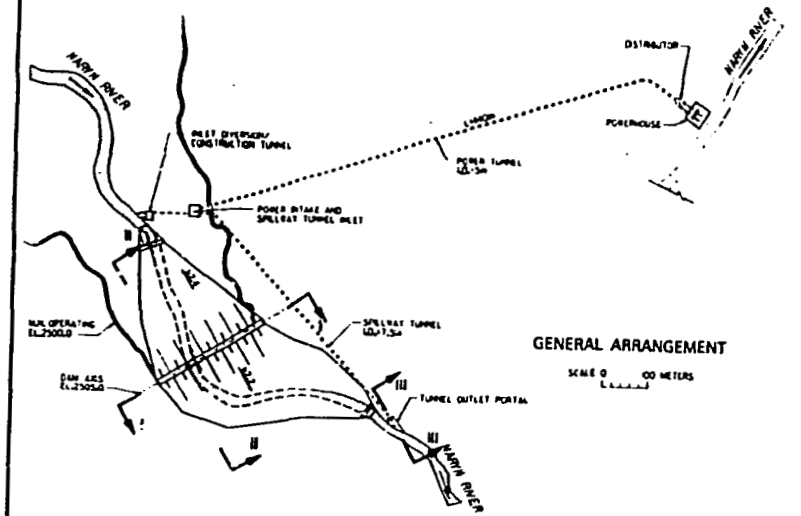
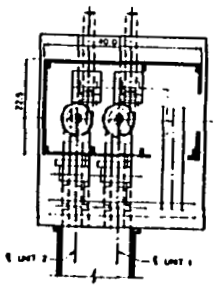


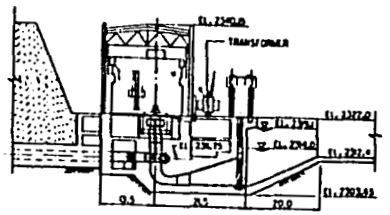
GENERAL ARRANGEMENT

SCALE 0 100 METERS



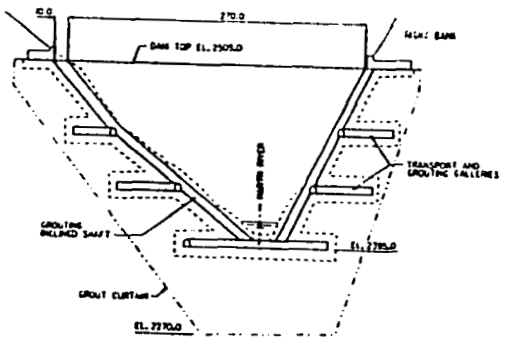
POWERHOUSE
GENERATOR FLOOR (EL. 2322.00)

SCALE 0 10 METERS



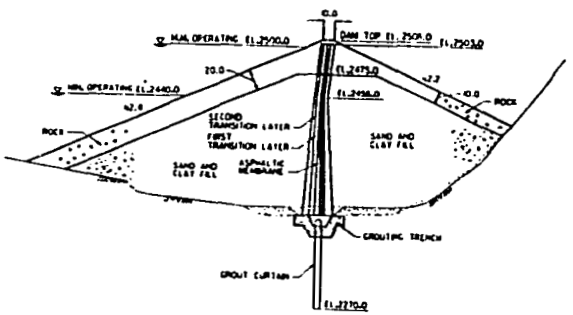
POWERHOUSE
TRANSVERSE SECTION (UNIT ℄)

SCALE 0 10 METERS



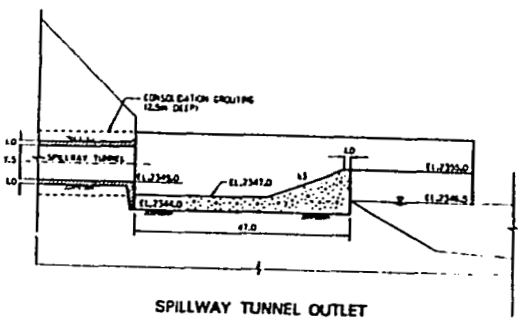
DAM SECTION I - I

SCALE 0 50 METERS



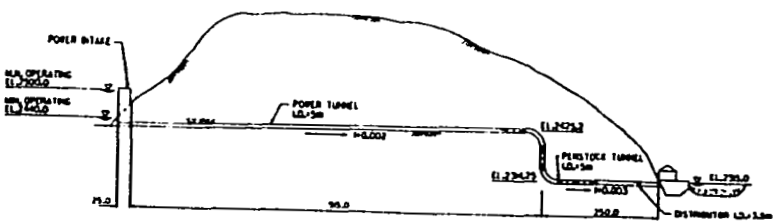
DAM SECTION II - II

SCALE 0 50 METERS



SPILLWAY TUNNEL OUTLET
SECTION III - III

SCALE 0 10 METERS



POWER TUNNEL PROFILE

SCALE 0 100 METERS

NOTE:
BASED ON THE TASHKENT HYDRO DESIGN INSTITUTE (THDI) LAYOUTS.

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KYRGYZSTAN
DJANKEL POWERPLANT

GENERAL ARRANGEMENT
PLAN VIEWS AND SECTIONS

DWG. NO. UN-03

AUGUST 1993

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Chapter 4

COST ESTIMATES AND PROJECT SCHEDULING

This chapter describes the general approach and methodology used to prepare cost estimates and preliminary construction schedules for the hydro projects under study. The chapter details the bases for labor, materials and construction equipment rates, and development of unit prices. Construction methodology and cost analyses for the major cost items are reviewed.

The description of project cost estimates and scheduling presented in this chapter is general in nature, and applies to each of the hydro sites under study. Specific cost estimate and construction schedule information for each individual project is presented in the following chapters.

4.1 Basis for Construction Costs

4.1.1 General

For preparation of the project cost estimates, site visits were conducted to each of the proposed project areas. Extensive discussions were held with the Kyrgyzstan State Energy Company (KSEC), the Tashkent Hydro Design Institute (THDI) and the Naryn Hydro Energy Construction Company (NHECC). The THDI engineers planned and designed most of the existing and future hydropower projects in Kyrgyzstan. The NHECC has been involved in the construction of all the Lower Naryn hydroelectric projects, including the Kambarata projects.

Cost estimates developed by the THDI engineers and cost estimators were discussed and reviewed. However, the cost estimates developed in previous years by THDI specialists do not reflect current market prices, and new estimates had to be developed to reflect current conditions. In the former Soviet Union, the prices were developed by a pricing committee which was responsible for all prices. Each State had a series of books (called Katalogs) which were developed for different categories of work, such as heavy engineering, buildings, hydro power, electrical, mechanical and miscellaneous work. Each item was thoroughly detailed so that the cost estimator had little trouble selecting the correct price estimate for each work item. No individual unit prices were developed by the estimator. There were 50 to 60 such books in the former Soviet Union. They were first developed in 1969 and

revised only twice, once in 1984 and again in 1991. In the intervening years, no revisions were needed as no price changes took place.

The responsibility for accurate unit prices thus rested with the State. There were very few changes in costs of materials such as cement, reinforcing, structural steel, explosives, diesel, and petroleum, and labor costs remained unchanged for several years, with the result that the estimated cost of the finished product did not significantly change from the original estimate.

Historically then, pricing a project has been a relatively straightforward matter of selecting appropriate unit costs from the price books for the selected items and extending them to arrive at a total price. Once determined, the cost would remain virtually unchanged for the duration of the contract. Construction work moved slowly but smoothly, without any apparent incentives or bonuses for a faster construction schedule.

In the past two years, however, there have been major political and economic changes in the former Soviet Union. The exchange rate has gone from 12 to 1,250 rubles per US dollar. Material and equipment costs are increasing rapidly to reflect international prices. Since it is expected that it will take another two years before any major international funding can be approved for construction of the projects under study, the cost estimates presented in this report reflect international prices adjusted to reflect the local conditions in Kyrgyzstan. Because of the current lack of previous experience in international bidding in Kyrgyzstan, an analysis of prices from India, Pakistan and China was performed to serve as a basis for the cost estimates in Kyrgyzstan. In addition, each site was studied to determine resource locations, topographic and subsurface conditions, high flood seasons, required temporary works, availability of utilities, and general accessibility to personnel, equipment and materials. An assessment was made of potential cost savings which could be achieved by use of local materials, and maximizing the use of local personnel during construction.

A March 1993 price level has been adopted for the cost estimates. This March 1993 level was used because it reflected the latest official prices from the Ministry of Economics. An exchange rate of 800 roubles per US dollar was used.

4.1.2 Build-up of Unit Prices

The major construction items were analyzed to develop prices for individual items. The prices are a combination of the market costs of important items such as labor, materials, and fuel, and construction equipment availability, operation and maintenance. The unit costs were not independently produced, but they do represent the influence of specific site conditions on construction methodology, the use and sufficiency of certain types of equipment and materials, and the development and application of engineering techniques.

A first step in the basic pricing was to determine the project parameters, assess the site conditions, study the staging and work areas, and then determine the major items of work. After the project was laid out and quantities established, a formal constructability review was made for each site, and a preliminary construction schedule developed. Start and finish times were determined for each major activity in the schedule, and the logic of all activities established.

The quantities and the preliminary construction schedule, along with material balance, construction technology, and equipment and material list comprised the bases upon which which individual and unit costs were derived and analyzed. A series of labor crews were then prepared to match each construction activity, and each crew was assigned specific tasks to be performed with the given equipment and materials, and within the established duration. Unit prices were developed using this procedure for all of major field items.

4.2 Price Information

Information has been developed for labor costs, materials costs and construction equipment rates for use in the project cost estimates as described below. Labor is expected to be of national origin. Most basic construction material is available in Kyrgyzstan, and the origin of materials and equipment was considered, either from the national market or as imported to Kyrgyzstan. Prices from India, Pakistan and China are presented in the following paragraphs and served as a basis to develop the cost estimates for Kyrgyzstan.

4.2.1 Labor Costs

Information on labor rates was obtained from the THDI specialists during the field visit in June 1993. A series of discussions were held with the THDI cost estimator, as well as with the contractor at the Kambarata 2 site as to the applicability of prevailing rates for hydropower project development. Based on these sources, construction labor rates were developed for various categories of workers. These rates, shown in Table 4-1, include all benefits, fringes, payroll costs (taxes, workers compensation, etc.), and other applied social costs.

Table 4-1 shows the current labor costs in Kyrgyzstan and are compared with average costs in India, Pakistan and China. The Kyrgyzstan labor costs were modified to reflect efficiency shortfalls arising from irregular communications and resource supplies and the lack of readily available tools and equipment.

The modified labor rates are shown alongside the actual labor rates in Table 4-1. These modified rates were used in the cost estimates developed for this study. All labor costs are for an 8-hour day and are in U.S. Dollars at the March 1993 level.

Table 4-1

LABOR COST (U.S. $ PER DAY)

Labor Category	Kyrgyzstan cost per day		Indian Labor Cost per day *	Pakistan Labor Cost per day **	Chinese Labor Cost per day ***
	Actual	Modified			
Common Labor	0.92	1.60	1.31	2.65	3.00
Equp. Operator	1.13	2.00	2.58	3.50	6.00
Carpenter	1.13	2.00	2.90	3.50	4.00
Mason	1.13	2.00	3.55	4.70	4.00
Mechanic	1.30	2.30	2.60	4.70	5.00
Electrician	1.30	2.30	2.60	4.70	5.00
Truck Driver	1.30	2.30	1.94	5.25	4.00

* Indian labor rates from Contractors in India (2/3 tier rate system)
** Pakistan labor rates from Ghazi Gariala project in Pakistan
*** Chinese labor costs from Ertan Project in China (4 tier rate system)

4.2.2 Materials

Prices for major materials such as cement, explosives, reinforcing and structural steel, aggregate, diesel fuel, lumber, asphalt, drill steel and bits in the former Soviet republic were supplied by the Estimating Group of the THDI. All this information was translated and discussed with the representatives of the THDI. The only material available in Kyrgyzstan

in large supply is cement which is manufactured 20 kilometers from Bishkek. Aggregate for all purposes would be processed at the site. All other materials would come either from Russia or Ukraine. With the break-up of the former Soviet Union, all materials except cement and concrete aggregates must be treated as foreign (imported) materials.

Table 4-2 presents a list of prices for major materials as given without any adjustments. These prices are at the March 1993 level. Explosives, steel, timber, diesel and asphalt would be imported for the construction of the projects.

Table 4-2

MATERIAL PRICE COMPARISON

Item or Description	March 1993 Kyrgyz-stan Prices	Prices in India *	Prices in China **	Average World Prices
Diesel per U.S. Gallon	0.45	0.88	1.4	1.5
Cement per ton	7.0	65	54	80
Structural Steel per ton	26	484	283	616
Readimix Concrete per Cu M	4.0	25	19	40
Fine Aggregate per ton	0.89	5		6.5
Coarse Aggregate per ton	0.59	5		5.0
Lumber, fir type per Cu M	12.50	226		453
Reinforcing per ton	26	419	295	550
Explosives (Dynamite sticks) per ton	1,000			2,200
Explosives (Ammonia nitrate)	75	430	427	

* Indian prices from contractors in India;
** Chinese prices from Ertan project, China

4.2.3 Construction Equipment Rates

The derivation of construction equipment rates applicable to the development of the hydroelectric projects in Kyrgyzstan is illustrated through the following example:

Hourly rate for a Dozer D7 (200 HP): In this example, it would be assumed that the purchase price of this equipment delivered in Kyrgyzstan is $127,500 (assuming supply from within the former Soviet Union). According to well-established and documented construction equipment guide books published in the U.S. (Dataquest Company of California), the average economic life of this equipment under average conditions is 10,000 operating hours.

Cost of Equipment (in Kyrgyzstan) **$127,500**

The annual cost of equipment parts and tyres (ground engaging components, or GEC) are also established from the standard reference books. The average fuel consumption of a well-maintained piece of construction equipment would normally be 0.2 kg per horse power per hour. These standard figures are used to derive the hourly equipment costs for Kyrgyzstan.

Economic life		**10,000 hours**
Average cost per hour		**$ 12.76**
Annual cost of parts		**$ 20,000**
(Cost per 2,080 hours)		**$ 9.6**
Repair Labor	**@ 2 MH/hr**	**$ 0.6**
Fuel	**@ 0.2 kg/HP=40 kg/HR**	**$ 2.3**
Ground Engaging Component (GEC -- Trac)		**$ 0.9**
Owning and operating cost per hour for Dozer D7 in Kyrgyzstan		**$ 26.2**

Hourly costs for the same equipment under U.S. conditions are given in Table 4-3, along with the modified costs used for countries like India and China. For each category of costs, factors were derived by comparison. Factors used for Kyrgyzstan costs are indicated in Table 4-3.

Table 4-3

EXAMPLE SHOWING HOURLY EQUIPMENT COST FOR A DOZER D7

Description	Depreci-ation	Parts	GEC	Re-pair Labor	Fuel, oil	Elec tric	Total cost/hr
U.S.Cost per hour	15.95	12.11	0.9	5.74	9.24	0.0	$43.94
Factors for coun-tries like China, India or Pakistan	1.1	1.2	1.1	0.1	1.0	0.5	
Typical D7 cost for above countries using factors	17.55	14.53	1.0	0.6	9.24	0.0	$42.92
Factors developed for Kyrgyzstan	0.8	0.8	1.0	0.1	0.25	0.2	
Typical cost per hour of ownership and operating a D7 in Kyrgyzstan using these factors	12.76	9.69	0.9	0.6	2.31	0.0	$26.26

Sample equipment hourly rates developed on the above principle are shown in Table 4-4. The depreciation, parts and GEC are shown separately to indicate a foreign component in the equipment cost. Former Soviet equipment costs would be low in comparison. The equipment rates shown below are derived using base data available from equipment guide books published in the U.S. The hourly cost components consist of depreciation, parts, ground engaging components, repair and maintenance labor, fuel, oil and grease, and electricity where applicable.

Table 4-4

HOURLY EQUIPMENT RATES

Equipment Description	Depreciation + Parts + GEC	Repair and maintenance Labor + FOG + Elec	Total Equipment cost in U.S. Dollars per hour
COMPRESSORS			
600 cfm diesel Rotary	8.93	2.29	11.22
1200 cfm diesel Rotary	14.45	3.93	18.38
DRILLING EQUIPMENT			
3.5" Air Trac with Drifter	12.28	0.62	12.90
4.5" Air Trac with Drifter	19.97	0.84	20.81
COMPACTORS			
Caterpillar 815B - 210 HP	23.04	3.78	26.82
Caterpillar 825C - 310 HP	34.25	5.46	39.71
TRACTOR/DOZERS			
Cat D8N Dozer - 286 HP	31.25	4.11	35.36
Cat D8N Dozer/Ripper - 286 HP	35.71	4.33	40.04
Cat D9N Dozer - 370 HP	48.30	5.17	53.47
Cat D9N Dozer/Ripper - 370 HP	54.03	5.42	59.45
Cat D10N Dozer - 520 HP	65.51	7.32	72.83
GRADERS			
Cat 12G Grader - 135 HP	12.79	1.94	14.73
Cat 14G Grader - 200 HP	22.36	2.59	24.95
WHEEL LOADERS			
Cat 966E FEL 3.25 Cu M - 216 HP	22.20	2.65	24.85
Cat 980C FEL 4.25 Cu M - 270 HP	29.60	3.54	33.14
Cat 988B FEL 5.4 Cu M - 375 HP	46.59	4.93	51.52

Table 4-4 (Continued)

HOURLY EQUIPMENT RATES

Equipment Description	Depreciation + Parts + GEC	Repair and maintenance Labor + FOG + Elec	Total Equipment cost in U.S. Dollars per hour
Cat 992C FEL 10.1 Cu M - 690 HP	97.61	9.11	106.72
EXCAVATORS			
Cat 225D 1 Cu M - 165 HP	20.01	3.03	23.04
Cat 235C 1.6 Cu M - 250 HP	36.56	4.78	41.34
Cat 245B 2.4 Cu M - 360 HP	53.83	7.20	61.03
CRANES			
Grove Hyd 60T 110' - 198 HP	34.69	4.15	38.84
Manitowoc Crawler 100T 200'- 287 HP	46.36	5.11	51.47
Manitowoc Crawler 155T 240'- 287 HP	58.14	6.44	64.58
Manitowoc Crawler 200T 280'- 334 HP	72.54	7.49	80.03
Manitowoc Crawler 350T 310'- 685 HP	147.71	14.07	161.78
PUMPS			
4" 1500 Liters/Min 10 M - 25 HP	1.54	0.21	1.75
6" 3750 Liters/Min 20 M - 60 HP	2.44	0.45	2.89
8" 6000 Liters/Min 30 M - 95 HP	2.98	0.69	3.67
TRUCKS			
Cat 769C 17/24 Cu M - 450 HP	32,50	4.39	36.89
Cat 773B 26/35 Cu M - 650 HP	42.46	6.05	52.51

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Table 4-4 (Continued)

HOURLY EQUIPMENT RATES

Equipment Description	Depreciation + Parts + GEC	Repair and maintenance Labor + FOG + Elec	Total Equipment cost in U.S. Dollars per hour
22000 liter Water truck - 330 HP	36.29	4.59	40.88
TUNNEL EQUIPMENT			
Eimco 22 .3 Cu M - 20 HP	5.65	0.61	6.26
Wagner ST 8a LHD 6 Cu M - 231 HP	46.39	3.89	50.28
VENTILATION			
24" Vent Fan - 40 HP	3.76	0.25	4.01
36" Vent Fan - 75 HP	5.85	0.38	6.23

4.3 Cost Estimate Components

For project cost estimates, the direct and indirect costs have been developed from the viewpoint of the contractor. This section reviews the various components of the cost estimates.

4.3.1 Direct Costs

Direct costs for work items have been estimated based on site visit information, layouts, quantities established from layouts and sections, available geological information and experience on similar work. The development of costs involved analysis of typical labor crews, equipment spreads and materials. The resulting costs represent total direct cost for those work items.

Direct costs are also provided for mechanical and electrical equipment items, including gates, valves, turbines, generators, transformers and transmission lines.

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4.3.2 Indirect Costs

Indirect costs include all costs that are not directly associated with individual items, but which are necessary for the proper completion of the project. The principal items contributing to indirect costs are the following:

1. Contractor supervisory, engineering and administration staff salaries.

2. Staff and project vehicles operation and maintenance.

3. Temporary construction such as access roads, bridges, laydown areas, fencing, parking and environmental protection measures.

4. Offices, trailers, water house, pipe shop, fabrication and welding shop, carpentry and smith shop.

5. Support systems such as water supply, compressed air, electrical, site communications, oxygen, etc.

6. General expenses such as office supplies, furniture, engineering supplies and equipment, telephones, computers, permits and licenses, legal and engineering expert consultants, medical and sanitary facilities, weather protection, signage, photographs, road and quarry area, lighting, and mess facilities.

7. Job insurance, bonds, taxes, payroll costs, local and national contributions (for labor and staff), etc.

8. Contractor's risk and contingency allowance.

9. Contractor's home office expense.

Based on the above discussions and overseas projects' experience, a 45% markup factor would encompass all of the above items for the Kyrgyz projects. Actual indirect costs were not established for each project in Kyrgyzstan.

4.3.3 Contingency

Contingency percentages for the project cost estimates were based on past Harza experience with similar projects. For civil costs, a 30% contingency was applied; for all other items (mechanical/electrical/other), a 20% contingency was used.

4.3.4 Engineering and Administration

A 10% allowance was included for engineering and administration.

4.3.5 Total Project Cost

The combination of direct costs, indirect costs, overall contingency, and engineering costs result in the total project cost. Allowances for escalation of costs and interest on borrowed money over the period of construction have not been included in the project cost estimates.

4.4 Bill of Quantities and Review of Major Items

Each project estimate was developed using a standard Bill of Quantities. The following paragraphs describe the work activities associated with each.

4.4.1 Mobilization and Demobilization

These costs are based on percentage of the total costs. All project mobilization for equipment, personnel and material is included.

4.4.2 Tunneling

All tunnel and shaft excavation should be accomplished using conventional drill and blasting methods. Tunneling costs were developed based on past experience on similar projects and from field data collected at several of the sites. The costs were developed on general experience of tunneling in granitic rock with these factors in mind:

1. Existing geological conditions
2. Access to the tunnel portals
3. Support requirements for portals and tunnel
4. Rock bolting
5. Shotcreting

Traditionally, shafts are more expensive than horizontal tunnels for the same diameter and location. The cost of shaft excavation was developed in relation to the cost of tunnels and no separate detailed calculations were performed.

4.4.3 Penstocks

Penstock steel would be imported from within the former Soviet republics as rolled and ready for field installation.

4.4.4 Mechanical and Electrical Equipment and Transmission Line

Price information for electrical and mechanical equipment supply was developed based on recent vendor quotes on similar equipment on other jobs of a similar nature, and from past experience on similar projects. This information is considered to be reasonably accurate.

4.5 Build-Up of Unit Prices

Typical unit prices were developed for major items of work and are illustrated in Table 4-5 for quick reference. All prices are per Cu M for excavation, fill and concrete items; and for steel and other items, the costs are per tonne in U.S.$ per unit. Detailed item analysis was performed for these items.

4.6 Project Construction Schedule

Project construction schedule have been prepared for each hydro projects under study and form the basis for the cost estimates. The schedules are presented in the following chapters.

Table 4-5

UNIT PRICES

Item Description	Cost per unit in US $
Excavations	
Common Excavation/Cu M	1.1
Rock Excavation/Cu M	4.1
Fills	
From excavation/Cu M	1.0
From Borrows/Cu M	2.1
Tunnels	
Horizontal/Cu M	56
Vertical/Cu M	86
Galleries/Cu M	44
Silos/Cu M	77
Concrete	
Concrete 200M/Cu M	100
Concrete 300M/Cu M	150
Concrete 400M/Cu M	220
Arch Dam/Cu M	110
Grout	
Grout/Cu M	75
Grout/Sq M	30
Contact/Sq M	8
Liners	
Penstock steel/Tonne	2,062
structural steel/Tonne	2,106
Rockbolts/Tonne	3,310

Chapter 5

THE KAMBARATA HYDROELECTRIC PROJECTS

5.1 Project Setting

The Kambarata Hydroelectric Project was originally planned by the Tashkent Hydro Design Institute (THDI) to include three hydroelectric stations, Kambarata No. 1 (upstream-most), No. 2 and No. 3 (downstream-most). In this study, we have only reviewed the Kambarata 1 and 2 projects. The Kambarata No. 3 project would only operate when the Toktogul reservoir is low.

5.1.1 Location

The Kambarata dam sites are situated in the middle part of the Naryn river between the Togoztural basin in the east and the Ketmentub basin in the west. The length of the area is about 100 km. The site of the Kambarata No. 1 dam has an asymmetrical profile. The valley is about 200 to 300 meters wide at the elevation of the proposed dam crest. The base of the valley is about 30 to 60 meters wide. The river surface is at about Elevation 950 to 955 meters.

Kambarata 2 will be located 15 kilometers downstream from the Kambarata 1 site. The Kambarata 1 and 2 powerplants are planned to be built on the Middle Naryn River, just upstream of the reservoir formed by the existing Toktogul Hydroelectric Project. The sites are located in the Talas Region of Kyrgyzstan, within the Toktogul Township ("Rayon"). THDI of Tashkent, Uzbekistan, performed feasibility studies (Technic and Economic Calculations) and final design (Proyekt) at both sites. For both plants, the feasibility studies for various alternatives were completed in 1982, and final design studies for the selected powerplant configurations were finalized in 1990. Currently, the construction by the Kyrgyzstan national contractor is under way at the Kambarata 2 powerplant, with a significant part of the underground and surface excavation works completed.

5.1.2 Topographic Mapping

Topographic maps are available from the previous project activities. The detail and quality of the existing material are adequate and correspond to the current projects status. The available mapping includes : aerial mapping, scale 1:12000, covering a significant stretch of the Naryn River which includes the two Projects development zones; maps at scale 1:5000 with contour intervals at 50 m, covering dams and powerplant locations, as well as over other sites facilities; maps at scale 1:2000, contour interval at 2 m., covering same features as the previous ones; various maps for particular plant components and material borrow

areas at scales between 1:500 and 1:1000, with contour intervals at 1 and 2 m; maps along existing and future road alignments at scale 1:2000.

5.1.3 Geologic and Geotechnical Investigations

The geologic structure of the area includes PreCambrian, Paleozoic and Cenozoic rocks. The basic rocks are intensively deformed and fractured by tectonic faulting. Major faults in the Kambarata area strike East-West. Some minor faults strike at about N 60 W.

Complete subsurface investigations based on bore holes, galleries and pits were performed during the previous project activities. Samples were tested in-situ and in laboratory for most of the rock formations encountered at the site. The investigations present the detail required by final design activities and permit constructability considerations and decisions. Based on these extensive investigations, following broad characteristics of both dam sites can be mentioned:

- Alluvium in the river channel consists mostly of sand and gravel. Local accumulations of sand and small beaches with boulders are also sometimes present. The depth of alluvium varies from one to eight meters in the river bed and reaches 10 to 15 m in the floodplain.

- Overburden on the valley walls at the dam site consists of colluvium overlying weathered rock. The depth of colluvium reaches between 5 and 15 m on the valley abutments. Most colluvium consists of sandy clays, sands and gravel and includes occasionally boulders of weathered rock. The colluvium is mixed with alluvium at the base of the valley wall and over the flatter areas. Generally, the colluvial areas appear to be stable but the general configuration that includes the significant valley slopes, as well as the high seismicity at this site, suggests that landslides always represent a potential here.

- Bedrock consists predominantly of intrusive rocks (granites, porphyritic granites, and grano-diorites), which are classified in 3 zones based on depth of the layer. In addition to the granitic rock, deposits of the sedimentary precambrian complex including limestones, marbles, and sandstones, all with a very advanced metamorphism, are present at the project site.

5.1.4 Hydrology

Project sites hydrology developed by the THDI designers is based on data recorded at the Utcherek Station between 1911 and 1977. The station is close to the Kambarata 2 dam site. The mean annual runoff amounts to 317 m^3/s. Almost 78 percent of the total occurs during the months of April to September, most of it generated by snowmelt. At Kambarata 1, the maximum annual inflow of 534 m^3/s was recorded in 1969/70. The minimum recorded was

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226 m^3/s in 1982/83.

Recorded flood peaks were analyzed statistically based on a series valid for both sites. The highest flood peak on record of about 2000 m^3/s occurred in 1966. The average value of the flood peak series was 1294 m^3/s over the record period (1910-1987). Highest values calculated are 4220 m^3/s (10000-yr flood), 3110 m^3/s (1000-yr flood), 2630 m^3/s (500-yr flood), and 2420 m^3/s (100-yr flood). Highest floods occur generally in may-june and approximate volumes were defined for the above peaks (i.e., the flood volume corresponding to the 10000-yr peak amounts to 13600 million m^3).

The low discharges were also investigated through frequency analyses for a series representing both sites. The lowest monthly inflow was recorded in January 1918 and amounted to 70.3 m^3/s.

Sediment concentration is quite high in the Naryn, especially during floods. Most of the sediment consists of suspended silt and sand, but a significant amount of bed load also appears to be transported through the dam sites reach of the river. Based on the recorded period of 1961 to 1986, an average suspended sediment discharge of 440 kg/s or 14 million tons/yr, was determined for the river reach which covers both sites. At a specific weight of 1.0 ton/m^3 determined in laboratory, the river transports in average about 14 million m^3 of suspended sediment each year.

5.2 The Existing Kambarata 1 Project Layout

The layout proposed by the THDI specialists consists of a 275 m-high dam, two combined power/spillway tunnels, four shaft and tunnel penstocks, an indoor, surface, 4-unit powerhouse and outdoors switchyard. The installed capacity of the plant amounts to 1900 MW (maximum net head of 185 m, 4-unit discharge of 1150 m^3/s). The average energy production is 5088 GWh/yr. Design head is 166.5 m and design unit discharge amounts to 270 m^3/s. Capacity at design parameters is 1600 MW. The proposed layout components (plan views and sections) are presented on Drawings K1-01 and K1-02.

5.2.1 Dam and Spillway

The high dam planned at the Kambarata 1 hydroelectric project, is to be built by the controlled blasting of the site canyon walls. The crest of this dam is at El.1225 m. At the normal maximum operating El.1190, total storage created amounts to 4650 million m^3 and the live volume, to 3430 million m^3. The dam crest would be as wide as 280 m and 600 m long, with face slopes varying between 1:6 (downstream) and 1:3 (upstream).

There are obviously a series of advantages attached to this construction procedure by controlled blasting: limited heavy construction equipment will be required at the site and, consequently, lighter access roads will be necessary; a smaller work force will be needed and

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dam site settlement and service areas required are much smaller; no construction roads to quarries are needed and, most of all, there will be no important diversion paths nor cofferdams to take care of water during construction.

Dikes, large cofferdams and small dams, all under 50 to 55 m high, have been built worldwide by this technique. Given its size however, the planned structure at Kambarata 1 represents a novelty and THDI specialists have spent significant research time and effort during the previous project phases to evolve a technique applicable to a much larger dam. Research concentrated on monitoring the behavior of existing blast dams and natural landslides, on building dam pilots by blasting, on laboratory testing, and mathematical modelling.

Dams built by canyon blasting and monitored included Baipaza on the River Vakhs, Medeo on Malaya Almatinka, Bariri (India), Burlykia on Burlykia, Kurpsay on Kurpsay, Utchterek on Utchterek, etc. Important investigations have been carried out at the experimental 50 m-high Burlykia dam, a fill blast produced with significant amounts of explosives which generated the dam by throwing (flinging down) the rock mass into the site. More recently (June 1989), a new method was investigated in order to reduce explosive requirements. In order to reduce the significant quantities of explosive required for such a high structure, the dynamics of the blast based on crater formation and ejection of debris in the direction of the valley (classical method currently used to blast-build smaller dams), was changed to a method based on conveniently generating weak planes in the abutments and creating rock slides, much like a natural avalanche that fills the valley. The experiment was tried by constructing the 42 m-high pilot dam at Utchterek, where enough controlled blast was produced to trigger a rockslide from the left abutment and to dam the valley with the slide at the desired parameters. The pilot was raised into a gorge with almost vertical walls in granitic rock, very similar to the bedrock at the planned dam on Naryn. Reports consider the experiment a success and the technique is proposed at Kambarata 1. Harza team visited the pilot and found that the 42 m-high structure is stable after four years and still at the initial shape and crest elevation, despite the occurrence of a powerful earthquake in August 1992 (magnitude of about 7.5 on the Richter scale).

It has to be mentioned however that the only structures higher or similar in height to the planned dam at Kambarata 1 which were monitored, were natural landslides in the Tian Shan range, including the 740 m-high Usoi landslide on the Mugab River in Tadzhikistan. The natural dam occurred in 1911 and was visited by the THDI designers. According to the reports, it is stable and impervious today, with a lake formed behind the slide. Other natural landslides of heights close to the proposed blast dam, occurred in the past within the Naryn river watershed. Two such sites were overflown by the Harza team, together with the Tashkent engineers. Both looked stable and one had a lake formed by the slide.

In addition, research activities by the THDI designers have focused on several technique aspects that needed additional clarifications in order to be applied to much larger structures,

including prediction of the blasted rock mix and fill dimensions, impermeability and fines generation and content, and stability under seismic conditions. Laboratory tests have shown that the rolling of the mass and the ensuing rock grinding and mixing with the overburden, generate the required fines percentage for dam imperviousness. It is claimed that this procedure has the potential to reduce explosives and fuel requirements to about 30 per cent of the quantities required by the crater formation technique.

Natural experiments, laboratory testing and mathematical modelling have produced a series of design parameters and construction procedures that were used in the final design activities. The 275 m-high dam proposed to be generated at the site by the rock sliding method requires the blasting of three cliffs located on the left bank. The blast is to be done in two steps :the smaller, upstream most cliff is to be blasted first, and about one month later, the larger two cliffs at few seconds interval.The total rock volume dislocated from the rock mass amounts to 260 million m^3, expanding to 340 million m^3 in the valley. One third of the expanded total, or about 112 million m^3, are sufficient to dam the river at the design elevation, the rest stays on the valley abutments. The quantity of explosives needed amounts to 247,500 tons, including 230,000 tons of potassium nitrate and 13,000 tons of diesel fuel. The explosives are to be stored in 40 m-high, 12 m-diameter silos excavated in granitic rock within the abutment to be blasted. The diesel fuel is pumped into the silos some 24 hours before the blast. Almost 80 such charge silos are necessary to contain the explosives (the silos have up to 5000 tons capacity) and will be connected to each other by horizontal galleries at the upper and lower ends. About 800 thousand m^3 of underground excavation requirements are estimated for the explosives transportation and storage facilities, including 450 thousand m^3 of large vertical shaft excavation in the charge chambers.

Based on experiments and research, THDI designers predict dam densities between 1.8 and 2.2 t/m^3, settlements less than 2 per cent, and fines in the rock mass of as much as 30 per cent. Although the percentage of fines predicted is in the normal range for seepage control, additional measures based on wet blanketing are considered necessary. One million m^3 of clayey soil and sand mixture is provided among the basic dam quantities, to be transported over the dam crest from deposits available 1.5 to 2 km downstream from the dam site. A barge would be used to dump the impervious material into the reservoir just upstream of the dam and it is considered that such dumping will eventually fill voids and block potential leaks during the first few years of operation. Wet blanketing can be carried out with the plant in full operation, although at lower reservoir elevations. Wet blanketing has previously been carried out at the Tarbela dam in Pakistan and was recently recommended for leak blockage at the 125 m-high Samanalawewa rockfill dam on the Walawe river in Sri Lanka.

It is obvious that a lot of efforts have been spent by the THDI designers and Kyrgyz authorities to extend the blast procedure to the planned dam at Kambarata 1. Despite all the mathematical modelling and experimental backup, two issues remain practically unanswered:

- All the artificial pilots and existing structures built by blasting canyon walls at various locations have maximum heights of 50 to 55 m; the only base for a 275 m-high dam blasting remains a mathematical model and few natural landslides which occurred in the past within the Tian Shan range;

- Fines obtained both by intrusive rock grinding and by mixing with overburden (basically of the same texture), although predicted to reach the percentage requirement for fill imperviousness, are unlikely to swell when wet and effectively plug the voids; as a contingency, provisions are made for wet blanketing by utilizing clayey soil from a borrow area downstream of the dam; however, the effectiveness of this procedure at heads of 275 m is another unproved factor; wet blanketing was applied or recently proposed to be applied at other sites, but these rockfill dams were invariably lower and usually had a design with an existing impervious central core, unlike the fill at Kambarata 1.

In order to define a range of cost estimates at Kambarata 1, the above aspects suggest the need to review at least one dam alternative built by a conventional construction procedure, in addition to the proposed structure. The conventional dam considered as an alternative at Kambarata 1 is a concrete double-curvature arch dam. This layout was analyzed as an alternative to the blast dam at the feasibility level of the project (1982) by the THDI engineers. This alternative is described in Section 5.3.

5.2.2 Power Intake

The combined power/spillway passages consist of two practically horizontal, 1070 m-long reinforced concrete-lined pressure tunnels with average excavation and internal diameters of 11.5 m and 10.0 m, respectively. The two portals are separated by 90 m of rock mass and the portal inverts are at El.1070 m. A small cavern accommodating four emergency slide gates (two per tunnel) operated by hoists and served by shaft and access tunnel, is excavated some 200 m downstream from the portals and crosses both tunnels. At a distance of 1035 m from the portals, 80 m-long and about 13 m-wide enlargements are excavated along the alignment of both tunnels, to permit the installation of manifolds for two penstocks takeoffs each. A second small cavern for four maintenance slide gates (two per tunnel) and hoists, accessed through a maintenance tunnel, is excavated just upstream of the enlargements and crosses both tunnels.

The 10000-yr design flood passing through the reservoir raises the level at El.1208 m. Thus, the structure presents a large freeboard of about 17 m.The surcharge of 18 m at design flood results in the flood peak attenuation from 4200 m^3/s, to 2630 m^3/s.Up to the penstock manifolds, tunnel capacities are 1315 m^3/s each with headwater at El.1190 (total capacity of 2630 m^3/s which is the routed peak of the design flow). Capacity at El.1098 representing the minimum operating level in the reservoir, amounts to 1680 m^3/s which covers

downstream irrigation requirements. Of the 1315 m^3/s one-tunnel maximum capacity, 575 m^3/s flow through the penstocks and 740 m^3/s are discharged through the spillway which consists of the continuation tunnel beyond the enlargement.

The combined power/spillway tunnels are to be driven mostly through granitic rock mass 500 m-deep. Doubly reinforced concrete liner is 0.7 to 1.0 m thick and rock grout consolidation 7 to 15 m deep is provided at all heavily jointed rock zones.

Beyond the enlargement, the penstocks have 115 m-deep vertical reaches, followed by 437 m-long horizontal tunnels to the powerhouse. Penstock shafts and tunnels are reinforced concrete lined and have interior diameters of 7.0 m. The steel liner starts some 260 m upstream of the powerhouse and the rock is grouted around distributor shafts and tunnels.

Hoist-operated slide gates are provided at the initiation of the spillway tunnels, downstream of the penstocks manifolds. Whenever the flow exceeds 575 m^3/s per tunnel, the gate is opened to discharge water through the spillway tunnel. About 80 per cent of the energy is said to be dissipated through aerated 115 m-deep, 10 m internal diameter drop shafts located immediately downstream of the gates (model tests were performed at the scale 1/45). The configuration of the drop shafts is intended to eliminate the cavitation danger. Downstream of the shafts, spillway tunnel are horseshoe-excavated to a 8 x 8 m size and lined with 0.8 m thick reinforced concrete. The horizontal spillway tunnels are provided with drainage holes to decrease underground water pressure. Residual flow energy is dissipated at the outlets in two regular dissipation basins 11 m-deep, size 30 x 67 m. These basins were also model-tested. Practically all the underground works and the surface powerhouse can be built before the dam blasts due to the favorable valley configuration downstream of the dam (power and spillway outlets and powerhouse are separated from the dam site by a very sharp river meander through high cliffs).

Construction Tunnel - A 1610 m-long construction tunnel is to be driven before the blasts, on the right bank of Naryn. The tunnel will be excavated with a horseshoe shape and lined with reinforced concrete to an interior diameter of 5.0 m. It will divert water during the construction of the underground power/spillway facilities. Its intake is conveniently located upstream the main tunnel portals at El.997 m, more than 70 m lower than power intake portals. With headwater at El.1090 m, construction tunnel capacity amounts to about 500 m^3/s (a reduced construction flood). The diversion tunnel is controlled by a 5.2 x 7.0 m slide gate operated by a hoist. Toward the end of the construction period, the downstream part of the construction tunnel will become the final part of the left spillway tunnel and its upper reach will be plugged with mass concrete.

5.2.3 Powerhouse

Kambarata 1 is a 140 m-long, 57 m-wide and 55 m-high surface structure, including the erection bay. It is an indoor-type powerhouse with four units located on the right bank of

the river, separated by a large meander from the blasted dam. The structure foundation is excavated mostly in massive granitic rocks and the maximum pit excavation is 20 m, down to El.935 m. The superstructure is designed as steel frame with concrete blocks filling (reinforced for shear) and the roof is structural steel profiles.

Immediately upstream of the powerhouse are the turbine guard slide gates for emergency and repairs at the units. The four 3.2 x 7.85 m slide gates are operated by hoists and a gantry is provided on the deck. The 7.0 m internal diameter penstocks are connected to the spiral case inlet diameter of 5.4 m by a 9.5 m-long transition steel section embedded in concrete.

Turbines are vertical shaft Francis-type machines. The design machine is a russian axial-radial "Normalized-type" unit under the denomination RO230/2733M2-V-560, rotating at 150 rpm. Unit installed capacity is 485 MW at 185 m net head. At the design head of 166.5 m, unit capacity is 412 MW. The machine centerline is at EL.952 m with a minimum submergence of 0.5 m with the Kambarata 2 powerplant in operation.

The design generator is also a russian machine with the denomination SV1175/319-40UHL4, rated at 475 MW. Other characteristics include Cos fi = 0.9, voltage 15.75 kV, 150 rpm. Generator floor is at El.966.6 m.

Four transformers TTSE-630000/500 are located on a deck at the downstream side of the powerhouse. The deck is located at El.966.6 m, some 8.0 m above design flood tailwater. Unit capacity is 630000 kVA and the voltage is 525/15.75 kV.

5.2.4 Switchyard

The 300 x 250 m outdoor 500 kV switchyard is located at about 300 m from the powerhouse on the right bank of the river (same bank as the powerhouse), at El.1050. About 300 m-long cable connects the powerhouse to the switchyard.

5.2.5 Transmission Interconnection

The transmission development for the Kambarata 1 project will require significant new transmission facilities. This development is required to satisfy the following objectives:

Deliver power to loads in the lake Issyk-Kul region

Export power to Kazakstan and Uzbekstan

Provide necessary transmission to meet single contingency conditions

Provide interconnection between K1 and K2 plants.

The construction schedule for new transmission would be coordinated with installation of units 1 through 4 at the Kambarata 1 plant. The lines between K1 and K2 could be constructed to meet the need for construction power at K1.

A 500 kV line from K1 to the north east can be terminated at the proposed Kemin substation or at a new substation site on the west end of lake Issyk-Kul. If a transmission line were constructed to the Kemin substation, then it would be approximately 260 km long. If the transmission line were extended to the lake Issyk-Kul area, then it would be approximately 330 km long. With the proposed circuit it will be possible to deliver power to supply electrical load demand in north east Kyrgzstan.

To export power to Kazakstan, it will be necessary to construct a 500 kV transmission line from the Kemin or Issyk-Kul substation into Kazakstan. The possible connection points are the existing Alma Ati or at Frunzenskaya substations. The selection of the connection point would be determined in consultation with the Kazakhstanenergo Company.

In addition to the transmission lines to the north east from the K1 site it is also necessary to construct a 500 kV circuit to the south. The line would be about 230 km long and would connect the K1 site substation to a new substation in the Osh load area.

5.2.6 Access Road

A two-lane, hard cover road transitable by heavy trucks and other construction equipment, as well as by city vehicles, is in operation presently and is still used for the Kambarata 2 site works. Portions of this road will probably have to be relocated to by pass the blasted dam and the future lake.

5.2.7 Construction Schedule

Construction of the proposed Kambarata 1 project, using controlled blasting technique, is estimated to require 96 months including construction of the dam, intake and powerhouse, installation and start-up of four units, and construction of the transmission line. Additional time will be required for engineering and final design, preparation of tender documents, bidding and selection of contractors. A construction schedule is shown in Exhibit 5-1.

5.2.8 Construction Cost Estimate

Chapter 4 describes the approach and methodology used to prepare the cost estimates. The chapter details the bases for labor, materials and construction equipment rates, unit prices, direct and indirect costs, contingencies and total construction cost. A general description of the cost analysis for the major cost items is also presented.

Total construction cost for the Kambarata 1 project is estimated at $ 1.67 billion at a March

1993 price level. Table 5-1 shows the estimated construction cost of the project by major item. The detailed cost estimate is presented in Exhibit 5-2.

Table 5-1

KAMBARATA 1 COST ESTIMATE
BLAST DAM

Item Description		Total in $$
General Items		27,000,000
Common Excavation		2,393,930
Rock Excavation		3,431,700
Underground Exc. - Tunnels		48,837,600
Underground Exc. - Vert. Tunnels		8,256,000
Backfill		1,617,000
Surface Concrete - M 200		10,400,000
Surface Concrete - M 300		18,420,000
Surface Concrete - M 400		220,000
Underground Concrete - M 200		26,180,000
Underground Concrete - M 300		60,490,000
Consolidation Grout		22,050,000
Grout Curtain		12,180,000
Steel		59,617,200
Blasting Material		115,927,800
Underground Exc. for "Blast" Dam		46,695,000
Mechanical, Electrical, Other		374,530,000
Gates, Cranes, Etc.		57,654,000
Switchyard		12,000,000
Substation		20,000,000
Transmission 500kV		26[illegible],044,000
Direct cost Total		1,191,944,230
Contingency, Civil work 40%		185,486,492
Contingency, Other work 20%		145,645,600
Subtotal		1,523,076,322
Engineering and Administration 10%		152,307,632
Project cost total at March 1993 level	**U.S. $**	**1,675,383,954**

5.3 Alternative Kambarata 1 Project Layout

The conventional dam considered as an alternative at Kambarata 1 was a concrete double-curvature arch dam with perimetral joint. This layout was analyzed as an alternative to the blast dam at the feasibility level of the project (1982) by the THDI engineers. The dam site is located at the initiation of the river meander which is otherwise completely covered by the blast in the previous alternative. Given the V-shaped valley at the dam site and, especially, the competent characteristics of the abutment rock, an arch dam is technically a sound configuration, worth analyzing. The alternative was eliminated in favor of the blast dam based on total cost considerations within the 1982 Feasibility Study. Under this study scope of work however, Harza considers that re-evaluating a conventional type of dam should help in better defining the cost range at Kambarata 1 for project ranking purposes. The arch dam alternative layout is shown on Drawings K1-03 and K1-04 and consists of the arch dam with surface overflow and low-level spillways, four penstocks in shafts and tunnels, a four-unit surface powerhouse and outdoors switchyard. The installed capacity of the plant amounts to 1700 MW (maximum net head of 166.8 m, 4-unit discharge of 1135 m^3/s). Design head is 150 m and net design discharge amounts to 264.5 m^3/s. The capacity at design parameters is 1440 MW. The average energy generation would be about 4,611 GWh/year.

5.3.1 Dam and Spillway

The top of the arch dam alternative and the lowest foundation block contact were set at El.1190 and 945 m, respectively. Thus, maximum height of this structure resulted 245 m, including the foundation block. The deepest part of the perimetral joint is located between El.978 and 982 m. The length of the dam along the top amounts to 690 m. Thickness of the largest cantilever at the joint is about 20 m and its height amounts to 212 m (ratio of about 1:10).

As mentioned, the feasibility determinations of this alternative have been done for comparison purposes only, about eight years earlier than the final design of the blast dam. For this reason, there is no complete equivalence between the two alternatives. The normal maximum operating level is 5 m lower at the concrete dam and, consequently, total and live reservoir volumes are slightly smaller. Also, the allowed surcharge at the design flood is much smaller (2 m against 17 m), and so is the total attenuation effect at design flood, leading to increased spillway capacity. Power characteristics also result different in the two configurations but parameters vary only within about ten percent and consequently, total and specific costs ranges can be defined with sufficient accuracy.

Both consolidation and curtain grouting are provided under the concrete arch dam. The 115 m maximum depth grout curtain (down to El.835 under the largest cantilever) is performed from galleries of 3.5 x 4.4 m and 2.5 x 3.0 m sizes, penetrating the foundation block at average vertical distances of 22.5 m. A 20 m-deep consolidation blanket is provided all over

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the rock contact. Two lines of drains down to El.905 and 870 under the maximum cantilever and separated by 15 m, are also drilled from galleries located within the foundation block.

Two flood discharge paths are provided at the dam : a 40 m-long (four 10 m-long openings) free overflow ogee spillway with the crest at El.1185, and a low level spillway consisting of five 18 m-long horizontal, steel lined, 5.0 m ID, ducts penetrating the central cantilever at El.1032.5 m (invert). The low level spillway is controlled by slide gates installed in a housing built on the downstream face of the dam at the end of the ducts and operated with hydraulic hoists from a deck at El.1043. The 10,000-yr design flood passing through the reservoir raises the level at El.1188 m. Thus, the structure presents a 2 m freeboard. The surcharge of 3.0 m at design flood results in a flood peak attenuation from 4200 m^3/s, to 3700 m^3/s. Only 12 to 14 percent of the routed flood peak is passed over the ogee and the rest is discharged through the low level gated orifices.

5.3.2 Power Intake

The intake structure of the arch dam was located on the left bank, having the invert at El.1080 m. The structure is adjacent to the upstream face of the dam, is separated by a contraction joint from the cantilevers, and accommodates inclined trash racks, as well as maintenance and emergency slide gates operated by hoists from the top of the dam. Four bell mouth shaped intakes lead to pressure conduits which include 80 m-deep vertical shafts, followed by 325 m-long tunnels leading to the surface powerhouse under a 8 percent slope. The shafts are excavated at 8.0 m size, steel lined and concrete backfilled to an internal diameter of 7.0 m. Rock consolidation grouting is to be performed beyond the liner over a depth of at least 5.0 m. Power tunnels are horse shoe-excavated at a 8.2 x 8.2 m-size, steel lined and concrete backfilled to a circular section with a 7.0 m internal diameter. Five m-deep consolidation grouting is also provided in the surrounding rock mass. A total of 1620 m shaft and tunnel length, corresponding to about 115,000 m^3 of underground excavation, is driven for the power conduits in the concrete dam alternative.

The power intake is provided with trashracks operated by crane, and controlled by four emergency and four maintenance gates operated by hoists.

5.3.3 Water Diversion

A 573 m-long construction tunnel is to be driven through the right abutment to divert the construction floods during dam construction. Inlet portal invert is conveniently located at El.971 m. The tunnel is controlled by one 10.2 x 15.0 m inlet gate operated by mobile crane. The practically horizontal tunnel is excavated with a horseshoe shape at the average dimensions of 15 x 11 m and lined with 40 to 70 cm reinforced concrete. Two rockfill cofferdams, both with impervious core, protect the dam construction site. The upstream and downstream fills have structural heights of 48 and 18 m, respectively. Under free flow conditions, the tunnel conveys close to the 10-yr flood of 1780 m^3/s. With headwater at

El.1014 m (the upstream cofferdam has the top at El.1015 m), the construction tunnel conveys the 50-yr construction flood of 2150 m^3/s. The downstream cofferdam with the top at El.980 m, presents a 1.2 m freeboard against the 50-yr flood stage (El.978.8 m). At the end of the construction, the diversion tunnel will be plugged with mass concrete over a length of 100 m, underneath the dam-foundation contact. The rock mass around the plug is to be consolidated by grouting over a 7 m depth.

5.3.4 Powerhouse and Equipment

Kambarata 1 is a 146 m-long, 50 m-wide and 55 m-high surface structure, including the erection bay. It is an indoor-type powerhouse with four units located on the left bank of the river, at about 300 m distance from the dam. The foundation of the structure is excavated mostly in massive granitic rocks and the maximum pit excavation is 50 m, down to El.955 m. During excavation and most of the concrete works, the powerhouse is not protected by the two cofferdams described above and will probably need a cellular protection dike until draft tube gates can be installed.

The superstructure is designed as steel frame with reinforced concrete walls and the roof is made of structural steel profiles. Plant main characteristics include a total installed capacity of 1700 MW and a guaranteed capacity at design head of 1400 MW.

At the upstream side of the powerhouse, the 7.0 m internal diameter penstocks are connected to the spiral case inlet diameter by a transition steel section embedded in concrete. No pre turbine guard gates are provided.

Turbines are vertical shaft Francis-type machines. The design machine is a russian axial-radial "Normalized-type" unit under the denomination RO230/791d-V-600, rotating at 136.4 rpm. The machine centerline is at EL.971.3 m with a minimum submergence of 1.7 m. Draft tube bulkheads operated by a crane from a downstream deck will control the eight openings of the draft tubes provided with central piers.

The design generator is also a russian machine with the denomination SV1380/230-44, rated at 425 MW. Other characteristics include Cos fi = 0.9, voltage 15.75 kV, 135.4 rpm. Generator floor is at El.986.65 m.

Four transformers TTSE-400000/500 are located on a deck at the downstream side of the powerhouse. The deck is located at El.986.65 m, some 3.65 m above design flood tailwater. Unit capacity is 400000 kVA and the voltage is 525/15.75 kV.

5.3.5 Switchyard

The 300 x 250 m outdoor 500 kV switchyard was planned on the right bank of the river at El.1050, at the same location as in the blast dam configuration. It is located at about 1300

m from the takeoff platform which is on the left bank and connected to the powerhouse by a 175 m-long cable tunnel excavated at a 6.3 x 5.0 m horseshoe shape and lined with a 40 cm thick reinforced concrete.

5.3.6 Transmission Interconnection

The transmission interconnection would be the same as the one described earlier for the blast dam alternative.

5.3.7 Access Road

A two-lane, hard cover road transitable by heavy trucks and other construction equipment, as well as by city vehicles, is in operation presently and is still used for the Kambarata 2 site works. Portions of this road would probably have to be relocated to by pass the dam location and the lake.

5.3.8 Construction Schedule

Construction of the proposed Kambarata 1 project, using a conventional arch dam, is estimated to require 96 months including construction of the dam, intake and powerhouse, installation and start-up of four units, and construction of the transmission line. Additional time will be required for engineering and final design, preparation of tender documents, bidding and selection of contractors. A construction schedule is shown in Exhibit 5-3.

5.3.9 Construction Cost Estimate

Chapter 4 describes the approach and methodology used to prepare the cost estimates. The chapter details the bases for labor, materials and construction equipment rates, unit prices, direct and indirect costs, contingencies and total construction cost. A general description of the cost analysis for the major cost items is also presented.

Total construction cost for the Kambarata 1 project is estimated at $ 1.85 billion at a March 1993 price level. Table 5-2 shows the estimated construction cost of the project by major item. The detailed cost estimate is presented in Exhibit 5-4.

Table 5-2

KAMBARATA 1 COST ESTIMATE
ARCH DAM

Item Description		Total in $$
General Items		27,000,000
Common Excavation		721,490
Rock Excavation		22,194,120
Underground Exc. - Tunnels		12,023,200
Underground Exc. - Vert. Tunnels		1,809,500
Backfill		1,029,420
Surface Concrete - M 200		16,380,000
Surface Concrete - M 350		387,409,000
Surface Concrete - M 400		50,336,000
Underground Concrete - M 200		19,205,000
Underground Concrete - M 300		3,630,000
Consolidation Grout		25,072,500
Grout Curtain		2,325,000
Steel		51,916,160
Mechanical, Electrical, Other		374,530,000
Gates, Cranes, Etc.		58,422,000
Switchyard		12,000,000
Substation		20,000,000
Transmission Line		264,044,000
Direct cost Total		1,350,047,390
Contingency, Civil work 30%		186,315,417
Contingency, Other work 20%		145,799,200
Subtotal		1,682,162,007
Engineering and Administration 10%		168,216,201
Project cost total at March 1993 level	**U.S. $**	**1,850,378,208**

5.4 The Existing Kambarata 2 Project Layout

The Kambarata 2 Project is currently under construction. Although the construction started before the Kambarata 1 initiation, important layout features are designed and built based on the assumption that the Kambarata 1 dam will be in place by the time the downstream development is completed or at least, very soon after completion. This concept is reflected in the low capacity of the spillway, as well as in the high plant capacity installation despite a rather negligible live storage in the Kambarata 2 reservoir. Drawings K2-01 and K2-02 reflect the proposed layout which consists of the blast dam, a power intake with three openings and three parallel power tunnels, a spillway tunnel, a 3-unit surface powerhouse and outdoors switchyard. The installed capacity of the plant amounts to 360 MW. The design net head of the installation is 47.5 m and the unit design discharge amounts to 280 m^3/s.

5.4.1 Dam and Spillway

A 62 m-high dam is to be built at the Kambarata 2 hydroelectric project by the controlled blasting of one of the site canyon wall. The crest of this dam is at El.960 m. At the normal maximum operating El.955 m, the total storage created amounts to 70 million m^3 and the live volume, to 8 million m^3.

Before selecting this construction procedure at the Kambarata 2 site, the THDI specialists have participated in extensive investigations at experimental dams having almost the same height. As mentioned earlier, these structures included the 50 m-high Burlykia fill dam (early 1980's), and more recently (June 1989), the 42 m-high pilot dam at Utchterek, where the controlled blast triggered a rockslide from the left abutment and dammed the valley at the predicted parameters. The pilot maintained its initial shape and crest elevation, despite the occurrence of a powerful earthquake in August 1992 (magnitude of about 7.5 on the Richter scale).

Natural experiments, laboratory testing and mathematical modelling have produced a series of design parameters that were used in the final design activities. A 62 m-high dam is proposed to be generated at the site by the rock sliding method, blasting one cliff located on the right bank. The total rock volume dislocated from the rock mass amounts to 3.6 million m^3, expanding to 5.2 million m^3 in the valley. One third of the expanded total, or about 1.7 million m^3, are sufficient to dam the river at the design elevation, the rest stays on the valley abutments. The quantity of explosives needed amounts to 2870 tons of "grammonit" (a conventional explosive). The explosive is to be stored in silos excavated in granitic rock within the abutment and connected by horizontal galleries at the upper and lower ends. The galleries are provided for explosive transportation and for blast pressure equalization purposes. About 8.4 thousand m^3 of underground excavation requirements are estimated for the explosives transportation and storage facilities, including 3.7 thousand m^3 of vertical shaft excavation in the charge chambers.

Based on experiments and research, THDI designers predict dam densities between 1.8 and 2.2 t/m^3, settlements less than 2 per cent, a dam crest as wide as 140 m and 550 m long, fines in the rock mass of as much as 30 per cent, face slopes varying between 1:3 (upstream) and 1:3.5 (downstream). The magnitude of potential infiltrations defined by calculations and models amount to 15 m^3/s during the first year of operation. THDI designers predict that the short period required by the reservoir siltation (4 to 5 years), and the high river turbidity, will lead to the natural siltation of the blasted rock and to gradual reduction of infiltration through the dam. However, additional measures based on wet blanketing are considered necessary. About 250,000 m^3 of clayey soil and sand mixture is provided among the basic dam quantities, to be transported over the dam crest from deposits available at the borrow area No.4, some 2 km downstream from the dam site. A barge would be used to dump the impervious material into the reservoir just upstream the dam and it is considered that such dumping will eventually fill voids and totally block leaks during the first few years of operation. Wet blanketing can be carried out with the plant in full operation, although at lower reservoir elevations.

The excavated spillway tunnel with ID of 11.5 m and upstream invert at El.913, becomes operational free-flow (complete section) when the reservoir level reaches El.925. Its capacity with the reservoir at El.955 (normal pool) amounts to 1790 m^3/s which is equal to the design flood as attenuated in Kambarata 1.

5.4.2 Power Intake

The power intake design consists of an inlet structure with invert at El. 930 m and three 580 m-long lined parallel power tunnels excavated at sizes between 9 and 10 m and lined with reinforced concrete to an 8.0 m internal diameter. On about 80 percent of their length, tunnels are reinforced concrete-lined. Beyond the liner, a 4 m-deep rock mass is consolidated by grouting. The power tunnels cross the 50 m-wide Iujnii fault starting some 140 m upstream of the powerhouse. Along this reach, the power conduit is designed as a steel lined pipe installed on articulated supports (compensators) within a gallery excavated in a horseshoe shape to a 11.5 x 11.5 m size and lined by 1.4 m reinforced concrete. It is claimed that the compensators within this gallery can accommodate tectonic movements of rock masses of up to 1.5 m. The steel liner is equipped with deformation couplings inside the gallery. A similar configuration was adopted to cross a 30 m-wide weak zone just upstream of the powerhouse. Due to high rock jointing, the steel liner actually starts 100 m before the Iujnii fault, along the regular tunnel design. The inlet and the power tunnels are currently excavated and the rock support is mostly in place. Harza team has visited the works which looked stable, including the power tunnel reaches that pass through the two tectonic faults. The steel liner sections, already rolled and protected by a primer, are stored outdoors on an adjacent yard.

The intakes have vertical trashracks and slots for maintenance and emergency slide gates. The slide gates hang in the slot above the flow section. Emergency gates are operated by

hoists and trashracks and maintenance gates, by crane.

5.4.3 Construction and Operation of Spillway Tunnel

A 400 m-long reinforced concrete tunnel is proposed to convey construction and operation design flood peaks. The tunnel is excavated in the left bank of Naryn. Over most of the alignment, it is excavated under a 14.7 m size horseshoe shape, lined to a 11.5 m internal diameter. The intake structure with the invert located at El. 925 m, has central pier and three pairs of slide gates : maintenance, maintenance/emergency, and emergency. The last two pairs are operated by hoists and the first, by crane installed on the intake structure deck.

The tunnel conveys in free flow regime a flood peak of 2110 m^3/s which probably corresponds to the 100-yr flood at the site (about 2420 m^3/s), as attenuated by the Kambarata 1 reservoir. In order to have this tunnel operating, the reservoir should be at least at El.925 m, which is already 25 m deep, out of a total dam height of 62 m. In other words, this tunnel will operate only after the blast and is not needed during construction. It can be used, however, to ensure a gradual filling of the lake before the powerhouse starts operating and consequently, to create the conditions for the wet blanketing operation. During operation, the tunnel capacity drops to 1790 m^3/s when working under pressure with the reservoir at El. 955 m (normal pool). Together with the power discharge of 840 m^3/s, the total discharge capacity of the powerplant amounts to 2630 m^3/s which corresponds to the 10000-yr design flood peak at Kambarata 1, as attenuated by that reservoir. Consequently, the spillway capacity at Kambarata 2 assumes the upstream 275 m-high blast dam already built and operational. Without that dam in place, the plant total discharge capacity is between 1500 and 1600 m^3/s short.

Due to the proximity of the Iujnii fault, no energy dissipation structure is provided at the outlet and a flip bucket is incorporated into the outlet portal. The flow is flipped in the river directly from the underground works and fills the river at about El.920 m.

5.4.4 Powerhouse

Kambarata 2 is a 120 m-long, 50 m-wide and 50 m-high surface structure, including the erection bay. It is an indoor-type powerhouse with three units located on the left bank of the river, 250 m downstream of the blasted dam. The powerhouse pit is currently excavated, mostly in massive granitic rocks and the maximum pit excavation is 30 m, down to El.883 m. The draft tube slabs are placed. The excavation is protected from the river by a cellular dike and the power tunnel outlet portals are fully supported above the pit. The pit walls are excavated almost vertically and seemed quite stable during the visit at the site.

The superstructure is designed as steel frame with concrete blocks filling (reinforced for shear) and the roof is structural steel profiles. Current powerhouse construction activities

take place under the protection of a cellular embankment and the tailrace penetration is planned to be done during the low flow season.

There are not turbine guard gates upstream of the units. The 8.5 m internal diameter steel liners are connected to the spiral case inlet diameter of 7.5 m by a 9 m-long transition steel section embedded in concrete.

Turbines are vertical shaft Francis-type machines. The design machine is a russian axial-radial "Normalized-type" unit under the denomination RO75/841-V, rotating at 100 rpm. The machine centerline is at EL.901.4 m with no submergence at one unit start up.

The design generator is also a russian machine with the denomination SV1262/172-60, rated at 120 MW. Other characteristics include Cos fi = 0.85, voltage 15.75 kV, 100 rpm. Generator floor is at El.912.9 m.

Two transformers, one TDTSE-200000/500 and one TDTSE-250000/500, are located on a deck at the downstream side of the powerhouse. The deck is located at El.912.9 m, some 6.5 m above design flood tailwater. First unit capacity is 200000 kVA and the voltage is 121/15.75 kV. The second unit capacity is 250000 kVA and the voltage amounts to 525/15.75.

5.4.5 Switchyard

The 400 x 250 m outdoor switchyard includes both 500 kV and 110 kV stations and is located at about 170 m from the powerhouse on the left bank of the river (same bank as the powerhouse), at El.915 m. About 250 m-long aerial cables connects the powerhouse to the switchyard.

5.4.6 Transmission Interconnection

Transmission for this plant will be provided by a connection to the existing 500 kV line between Toktogul Hydro Electric Power Station and the Frunzenskaya substation. One single circuit line will be constructed from the substation at the K2 plant and follow a right of way to reach the connection point with the existing line. It will be approximately 47 km long.

5.4.7 Access Road

A two-lane, hard cover road transitable by heavy trucks and other construction equipment, as well as by city vehicles, is in operation presently and is currently used for the Kambarata 2 site works.

5.4.8 Construction Schedule

Construction of the proposed Kambarata 2 project, using controlled blasting technique, is estimated to require 28 months including construction of the dam, intake and powerhouse, installation and start-up of three units, and construction of the transmission line. Additional time will be required for engineering and final design, preparation of tender documents, bidding and selection of contractors. A construction schedule is shown in Exhibit 5-5. This schedule was used as a basis for the project cost estimate presented in the next section.

5.4.9 Construction Cost Estimate

Chapter 4 describes the approach and methodology used to prepare the cost estimates. The chapter details the bases for labor, materials and construction equipment rates, unit prices, direct and indirect costs, contingencies and total construction cost. A general description of the cost analysis for the major cost items is also presented.

Total construction cost for the Kambarata 2 project is estimated at $ 260.7 million at a March 1993 price level. Table 5-3 shows the estimated construction cost of the project by major item. The detailed cost estimate is presented in Exhibit 5-6.

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Table 5-3

KAMBARATA 2 COST ESTIMATE
BLAST DAM

Item Description		Total in $$
General Items		1,700,000
Common Excavation		585,035
Rock Excavation		13,120
Tunneling		8,601,600
Backfill		1,064,910
Wet Blanket		800,000
Underground Concrete		31,740,000
Surface Concrete		28,935,000
Consolidation Grout		2,088,000
Contact Grout		1,073,600
Shotcrete		112,500
Steel		16,504,076
Blast Material		3,587,500
Blast Tunnels		0
Mechanical, Electrical, Other		69,030,000
Switchyard		6,000,000
Transmission Line		17,578,000
Direct cost Total		189,413,341
Contingency, Civil work 30%		29,041,602
Contingency, Other work 20%		18,521,600
Subtotal		236,976,543
Engineering and Administration 10%		23,697,654
Project cost total at March 1993 level	**U.S. $**	**260,674,197**

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5.5 The Kambarata 2 Conventional Earth Dam Alternative Project Layout

There is little, if any, Western experience in building permanent dam structures by blasting. This is especially true for storage dams which are part of large powerplant developments. For this reason, Harza considers that evaluating a dam alternative based on a conventional construction procedure would greatly help in defining the range of project cost estimate for ranking purposes. The conventional dam considered by Harza as a viable alternative at Kambarata 2 is a fill structure (sand and pebble), with central impervious screen built by cement grouting. This alternative was previously studied by THDI specialists and eliminated in favor of the blast dam based on total cost considerations at the 1982 Feasibility Study. Unlike the proposed development, the alternative was studied only under the conservative assumption that the construction of the dam at Kambarata 1 is delayed, mainly due to funding availability. As such, two obvious implications of the development were taken into consideration in performing the cost estimate :

- Without the Kambarata 1 reservoir to control the design flood, spillways at the fill dam were designed for the full capacity of the 10000-yr flood of 4200 m^3/s;

- For this conventional dam at Kambarata 2, a proper scheme to take care of water during construction was added; the capacity of this additional waterway corresponds to the 20-yr flood which amounts to about 2000 m^3/s.

In order to have a wide range of estimates at Kambarata 2, and to account for the delay at the large upstream reservoir, staged plant installations were also considered, specifically under two scenarios : a final installation of 360 MW as planned, and a smaller installation that would correspond to a much larger than expected delay at Kambarata 1.

The layout adapts a fill dam similar in configuration to the structure considered at the feasibility study, to the existing works at the site. As compared to the feasibility studies, the new dam is located some 240 m downstream, reaching with the toe the old tailrace end. The powerhouse foundation is currently excavated about 250 m downstream from the feasibility location. The layout presented on Drawings K2-03 and K2-04 consists of the fill dam, a power intake, three pressure tunnels leading to the surface, indoor powerhouse, a mid-level tunnel spillway, a water diversion tunnel which assumes a spillway function after plant commissioning, and an outdoors switchyard. The three power tunnels, the mid-level spillway tunnel and the powerhouse foundation have all been excavated and supported. Consequently, all layout components but the dam and the diversion/spillway tunnel are the same as in the proposed alternative for Kambarata 2.

5.5.1 Dam and Spillway

The valley presents little change between the feasibility location and the new selected one. Dam top elevation is the same (960 m) and height is about the same (62 m at maximum section). The dam profile was slightly revised by providing a higher upstream prism with top El. at 915 m. This dam body is built as an upstream cofferdam to protect the dam site from the 20-yr flood peak of 2000 m^3/s, is finally incorporated into the main dam. The downstream prism representing the downstream cofferdam is the same as in the feasibility study. The central part of the dam is made impervious by constructing a cement kernel in a three-stage grouting procedure performed from elevations 915, 943, and the top of the dam. Underneath the impervious core, a grout curtain about 50 m-deep seals the foundation.

Assuming significant delays in the construction of the Kambarata 1 dam and a plant design discharge of 840 m^3/s at this site, the spillway design flood amounts to 3360 m^3/s (the balance of the 10000-yr design flood that does not pass through the powerhouse). The existing spillway tunnel capacity with reservoir at El.960 (no freeboard) amounts to only 1880 m^3/s which is about 1500 m^3/s short. In addition to this consideration, this type of conventional dam will require a proper care of water configuration and the excavated construction/spillway tunnel cannot divert water from the river bed level. The existing tunnel with ID of 11.5 m and upstream invert at El.913, becomes operational full-flow only when reservoir level reaches El.925 which is way too high for a cofferdam construction. The preliminary solution adopted at this stage was to build an additional construction tunnel on the left bank of the river, in the space available between the dam and the excavated construction/spillway tunnel. The new 400 m-long tunnel is to be excavated with a horseshoe shape and lined with reinforced concrete to an internal diameter of 13.0 m. Inlet invert is at El.904 and outlet at 901, for a low slope of 0.0075. The tunnel will be able to divert about 2100 m^3/s in free flow (slightly more than the 20-yr flood). To install the required flood control at the structure during operation, this tunnel will be kept operational for the project life. With headwater at El.955 (normal pool), the tunnel adds about 2430 m^3/s capacity which is more than the control shortage and would enable the scheme to discharge the design flood of 4200 m^3/s even without the plant in operation. In order to keep in operation the tunnel, a complete intake structure with emergency and maintenance gates, hoists, and mobile crane, will have to be provided at the upstream end.

5.5.2 Power Intake

As mentioned earlier, the inlet and the power tunnels are currently excavated and the rock support is mostly in place.

5.5.3 Powerhouse, Equipment, and Switchyard

All these layout components are the same as incorporated in the blast dam alternative at

Kambarata 2. No works are completed at the switchyard location but the place looked stable and well drained.

5.5.4 Transmission Interconnection

The transmission interconnection would be the same as the one described earlier for the blast dam alternative.

5.5.5 Access Road

A two-lane, hard cover road transitable by heavy trucks and other construction equipment, as well as by city vehicles, is in operation presently and is used for the current site works.

5.5.6 Construction Schedule

Construction of the proposed Kambarata 2 project, using a conventional earth fill dam, is estimated to require 32 months including construction of the dam, intake and powerhouse, installation and start-up of three units, and construction of the transmission line. Additional time will be required for engineering and final design, preparation of tender documents, bidding and selection of contractors. A construction schedule is shown in Exhibit 5-7.

5.5.7 Construction Cost Estimate

Chapter 4 describes the approach and methodology used to prepare the cost estimates. The chapter details the bases for labor, materials and construction equipment rates, unit prices, direct and indirect costs, contingencies and total construction cost. A general description of the cost analysis for the major cost items is also presented.

Total construction cost for the Kambarata 2 project is estimated at $ 280.9 million at a March 1993 price level. Table 5-4 shows the estimated construction cost of the project by major item. The detailed cost estimate is presented in Exhibit 5-8.

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Table 5-4

KAMBARATA 2 COST ESTIMATE
EARTH FILL DAM

Item Description		Total in $$
General Items		3,400,000
Common Excavation		591,635
Rock Excavation		50,430
Tunneling		12,056,800
Dam Embankment		4,406,400
Backfill		1,064,910
Underground Concrete		36,294,000
Surface Concrete		29,835,000
Consolidation Grout		4,599,000
Contact Grout		1,265,600
Shotcrete		112,500
Steel		16,562,001
Concrete Plug Blast Tunnels		714,000
Mechanical, Electrical, Other		69,030,000
Switchyard		6,000,000
Transmission Line		17,578,000
Direct cost Total		203,560,276
Contingency, Civil work 30%		33,285,683
Contingency, Other work 20%		18,521,600
Subtotal		255,367,559
Engineering and Administration 10%		25,536,756
Project cost total at March 1993 level	**U.S. $**	**280,904,315**

5.6 The Staged Kambarata 2 Project

This alternative was considered if there is a delay in building the Kambarata 1 dam. With the sediment amount transported by Naryn river during annual floods, the life of the Kambarata 2 reservoir might be limited to only 6 to 7 years. The plant would soon start to operate practically in a run-of-river regime and a large installation might not be economically attractive. Under these conditions, only two units could be installed initially, with the third unit coming when Kambarata 1 dam is in place. All existing works can be protected and preserved, bulkheads erected at the power tunnels and powerhouse bays partially built.

The total estimated costs presented in Tables 5-3 and 5-4 would be reduced by about $ 30 million.

CONSTRUCTION SCHEDULE FOR KAMBARATA 1 HYDRO PROJECT IN KYRGYZSTAN

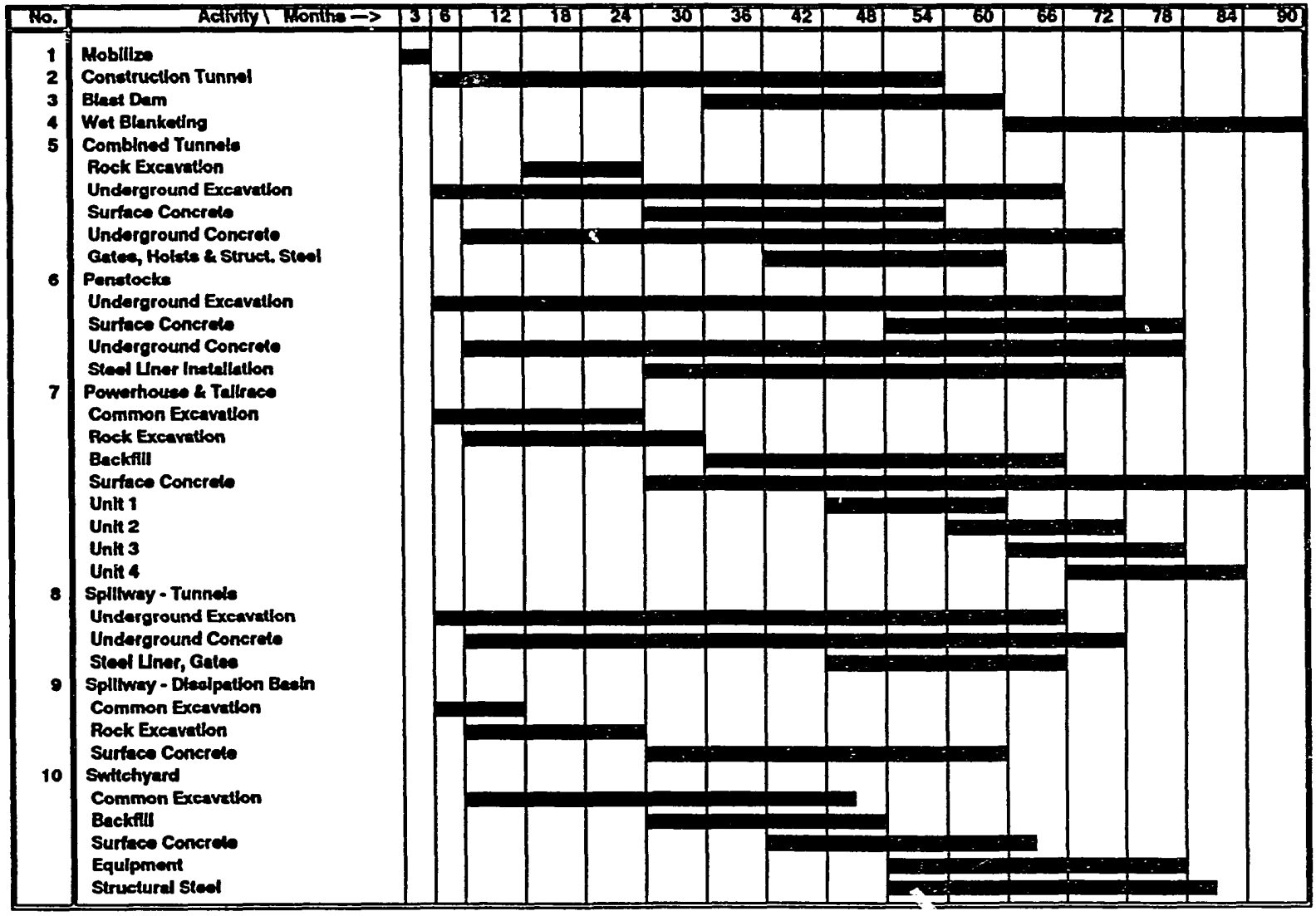

EXHIBIT 5-1

K1 "BLAST" FILL DAM All Costs in US Dollars

COST ESTIMATE FOR KAMBARATINSK # 1

ITEM DESCRIPTION	TOTAL COST
General Items	27,000,000
Common Excavation	2,393,930
Rock Excavation	3,431,700
Underground Excavation - Tunnels	48,837,600
Underground Excavation - Vertical Tunnels	8,256,000
Backfill	1,617,000
Surface Concrete - M 200 Concrete	10,400,000
Surface Concrete - M 300 Concrete	18,420,000
Surface Concrete - M 400 Concrete	220,000
Underground Concrete - M 200 Concrete	26,180,000
Underground Concrete - M 300 Concrete	60,490,000
Consolidation Grout	22,050,000
Grout Curtain	12,180,000
Steel	59,617,200
Blasting Material	115,927,800
Underground Excavation For "Blast" Dam	46,695,000
Mechanical, Electrical, and Other	374,530,000
Gates, Cranes, Etc.	57,654,000
Switchyard	12,000,000
Substation	20,000,000
Transmission 500kV	264,044,000
Total	1,191,944,230
Contingency	331,132,092
Total with Contingency	1,523,076,322
Engineering & Administration	152,307,632
Project cost at March 1993 Level	1,675,383,954
All Costs in US Dollars	

K1 "BLAST" FILL DAM

All Costs In US Dollars

COST ESTIMATE FOR KAMBARATINSK # 1

KYRGYZSTAN LABOR RATES, INTERNATIONAL MATERIAL PRICES AND MODIFIED EQUIPMENT RATES, AT MARCH 1993 LEVEL

BLAST - FILL DAM ESTIMATE

Item #	Description		Quantity	Unit	Rate	Total
1	General Items					
1.1	Mobilization and Demobilization		1	LS	25,000,000	25,000,000
1.2	Access Roads		1	LS	1,000,000	1,000,000
1.3	Housing and Camp		1	LS	1,000,000	1,000,000
						27,000,000
2	Total Excavations & Backfills					
2.1	Common Excavation	Cu M				
2.11	Downstream Cofferda	1,300				
2.12	Powerhouse	98,000				
2.13	Tailrace	48,000				
2.14	Switchyard	981,000				
2.15	Spillway Tunnel	27,000				
2.16	Roads	1,021,000				
	Total Qty	2,176,300				
	Total Cost Item 2.1		2,176,300	Cu M	1.10	2,393,930
2.2	Rock Excavation	Cu M				
2.21	Inlet Portal	5,000				
2.22	Powerhouse	236,000				
2.23	Tailrace	49,000				
2.24	Switchyard	7,000				
2.25	Spillway Tunnel	55,000				
2.26	Spillway Area	27,000				
2.27	Roads	458,000				
	Total Qty	837,000				
	Total Cost Item 2.2		837,000	Cu M	4.10	3,431,700

K1 "BLAST" FILL DAM

All Costs In US Dollars

COST ESTIMATE FOR KAMBARATINSK # 1

KYRGYZSTAN LABOR RATES, INTERNATIONAL MATERIAL PRICES AND MODIFIED EQUIPMENT RATES, AT MARCH 1993 LEVEL

BLAST - FILL DAM ESTIMATE

Item #	Description		Quantity	Unit	Rate	Total
2.3	Underground Excavati - Tunnels	Cu M				
2.31	Construction Tunnel	69,000				
2.32	Spillway Passages	266,000				
2.33	Roads	20000				
2.34	Miscellaneous	328000				
2.35	Spillway Tunnel	66100				
2.36	Penstock	123,000				
	Total Qty	872,100				
	Total Cost Item 2.3		872,100	Cu M	56	48,837,600
2.4	Underground Excavati - Vertical Tunnels	96,000				
	Total Qty	96,000				
	Total Cost Item 2.4		96,000	Cu M	86	8,256,000
2.5	Backfill	Cu M				
2.51	Powerhouse	180,000				
2.52	Tailrace	42,000				
2.53	Switchyard	268,000				
2.54	Roads	280,000				
	Total Qty	770,000				
	Total Cost Item 2.5		770,000	Cu M	2.10	1,617,000
3	Surface Concrete					
3.1	M 200 Concrete	Cu M				
3.11	Powerhouse	50,000				
3.12	Tailrace	10,000				
3.13	Switchyard	19,000				
3.14	Spillway Tunnel	17,000				
3.15	Other areas	8,000				
	Total Qty	104,000				
	Total Cost Item 3.1		104,000	Cu M	100	10,400,000

K1 "BLAST" FILL DAM

All Costs In US Dollars

COST ESTIMATE FOR KAMBARATINSK # 1

KYRGYZSTAN LABOR RATES, INTERNATIONAL MATERIAL PRICES AND MODIFIED EQUIPMENT RATES, AT MARCH 1993 LEVEL

BLAST - FILL DAM ESTIMATE

Item #	Description		Quantity	Unit	Rate	Total
3.2	M 300 Concrete	Cu M				
3.21	Construction Tunnel	10,000				
3.22	Spillway Passage	10,000				
3.23	Powerhouse	84,800				
3.24	Switchyard	4,800				
3.25	Spillway Tunnel	13,200				
	Total Qty	122,800				
	Total Cost Item 3.2		122,800	Cu M	150	18,420,000
3.3	M 400 Concrete					
3.31	Miscellaneous	1,000				
	Total Qty	1,000				
	Total Cost Item 3.3		1,000	Cu M	220	220,000
4	Underground Concret					
4.1	M 200 Concrete	Cu M				
4.11	Spillway Passage	6,000				
4.12	Penstocks	133,000				
4.13	Miscellaneous	48,000				
	Total Qty	187,000				
	Total Cost Item 4.1		187,000	Cu M	140	26,180,000
4.2	M 300 Concrete	Cu M				
4.21	Construction Tunnel	28,000				
4.22	Spillway Passage	135,000				
4.23	Penstocks	82,000				
4.24	Switchyard	4,800				
4.25	Spillway Tunnel	13,200				
	Total Qty	263,000				
	Total Cost Item 4.2		263,000	Cu M	230	60,490,000

K1 "BLAST" FILL DAM

All Costs In US Dollars

COST ESTIMATE FOR KAMBARATINSK # 1

KYRGYZSTAN LABOR RATES, INTERNATIONAL MATERIAL PRICES AND MODIFIED EQUIPMENT RATES, AT MARCH 1993 LEVEL

BLAST - FILL DAM ESTIMATE

Item #	Description		Quantity	Unit	Rate	Total
5	Grout					
5.1	Consolidation Grout	Cu M				
5.11	Construction Tunnel	12,000				
5.12	Spillway Passage	186,000				
5.13	Penstocks	59,000				
5.14	Switchyard	14,000				
5.15	Miscellaneous	23,000				
	Total Qty	294,000				
	Total Cost Item 5.1		294,000	Cu M	75	22,050,000
5.2	Grout Curtain	Cu M				
5.21	Construction Tunnel	29,000				
5.22	Spillway Passage	105,000				
5.23	Penstocks	200,000				
5.24	Switchyard	55,000				
5.25	Miscellaneous	17,000				
	Total Qty	406,000				
	Total Cost Item 5.2		406,000	Sq M	30	12,180,000

K1 "BLAST" FILL DAM

All Costs In US Dollars

COST ESTIMATE FOR KAMBARATINSK # 1

KYRGYZSTAN LABOR RATES, INTERNATIONAL MATERIAL PRICES AND MODIFIED EQUIPMENT RATES, AT MARCH 1993 LEVEL.

BLAST - FILL DAM ESTIMATE

Item #	Description	Quantity	Unit	Rate	Total
6	Steel				
6.1	Penstock Steel Liner	26,000	Tonne	2,062	53,612,000
6.2	Structural Steel	2,600	Tonne	2,106	5,475,600
6.3	Misc. Rockbolts, Etc.	160	Tonne	3,310	529,600
	Total Cost Item 6				59,617,200
7	Blasting Material				
7.1	Ammonia Nitrate	229,000	Tonne	429	98,241,000
7.2	Diesel Fuel	13,300	Tonne	296	3,936,800
7.3	Explosives	5,000	Tonne	2,750	13,750,000
	Total Cost Item 7				115,927,800
8	Underground Excavation For "Blast" Dam				
8.1	Vertical Silos	447,000	Cu M	44	19,668,000
8.2	Lateral Galleries	351,000	Cu M	77	27,027,000
	Total Cost Item 8				46,695,000
9	Mechanical, Electrical, and Other				
9.1	Francis Units 485 Mw	4	Ea	42,180,000	168,720,000
9.2	Transformers	4	Ea	7,760,000	31,040,000
9.3	Generators	4	Ea	38,800,000	155,200,000
9.4	Miscellaneous Mech.	1	LS	13,750,000	13,750,000
9.5	Miscellaneous Elec.	1	LS	5,820,000	5,820,000
	Total Cost Item 9				374,530,000

K1 "BLAST" FILL DAM

All Costs in US Dollars

COST ESTIMATE FOR KAMBARATINSK # 1

KYRGYZSTAN LABOR RATES, INTERNATIONAL MATERIAL PRICES AND MODIFIED EQUIPMENT RATES, AT MARCH 1993 LEVEL

BLAST - FILL DAM ESTIMATE

Item #	Description	Quantity	Unit	Rate	Total
10	Gates, Cranes, Etc.				
10.1	Gates, Hoists, Etc.	1	LS	47,139,000	47,139,000
10.2	Cranes	1	LS	10,515,000	10,515,000
	Total Cost Item 10				57,654,000
11	Switchyard	1	LS	12,000,000	12,000,000
12	Substation	1	LS	20,000,000	20,000,000
13	Transmission 500kV	706	Km	374,000	264,044,000
					1,191,944,230
	Contingency, Civil work	40%			185,486,492
	Contingency, All other work	20%			145,645,600
					1,523,076,322
	Engineering and Administration	10%			152,307,632
	Total Cost @ March 1993 Level				1,675,383,954

10-Sep-93

KAMBARATA 1 ARCH DAM SCHEDULE

CONSTRUCTION SCHEDULE FOR KAMBARATA 1 HYDRO PROJECT IN KYRGYZSTAN

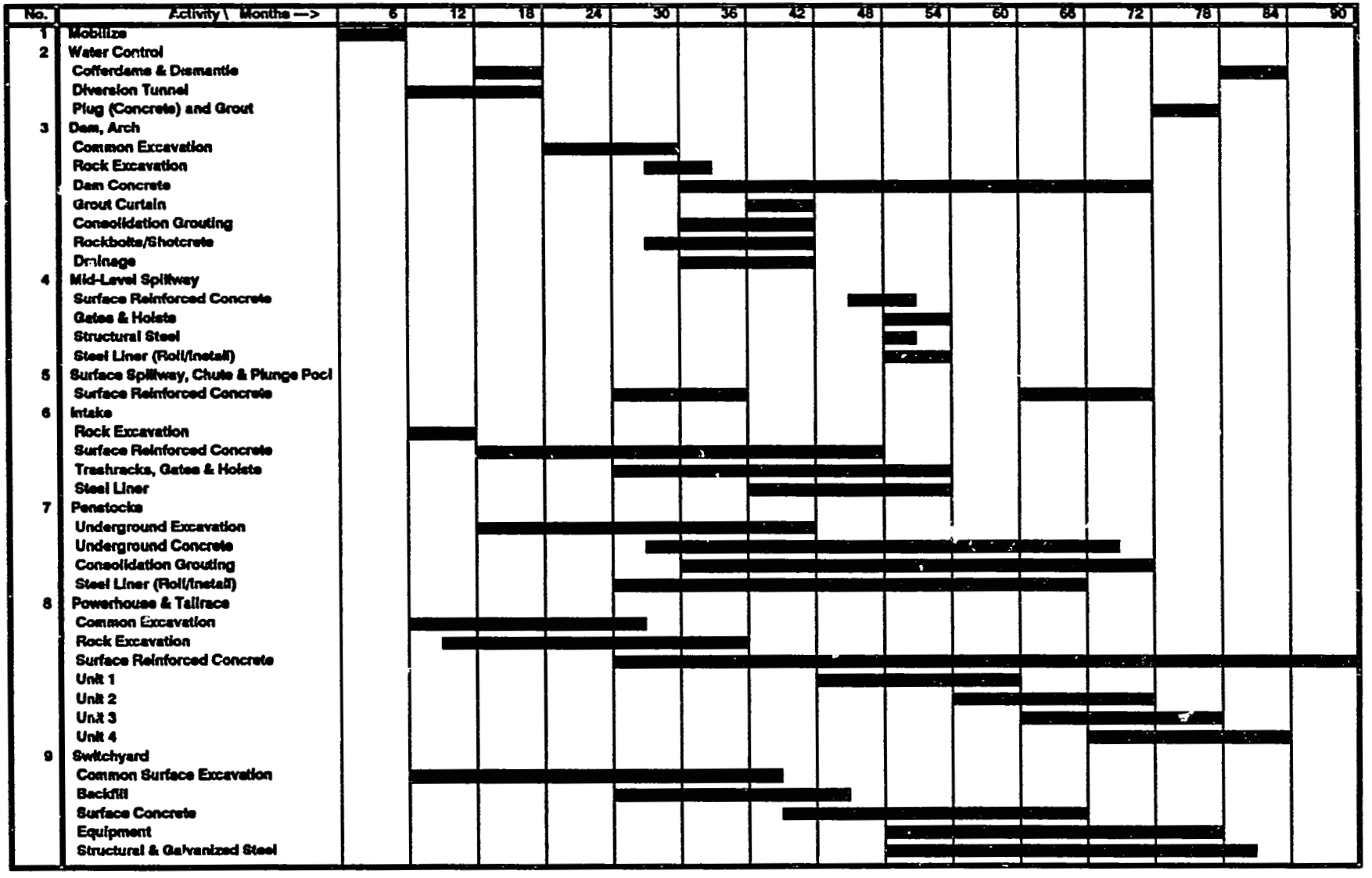

EXHIBIT 5-3

K1 CONCRETE ARCH All Costs in US Dollars

COST ESTIMATE FOR KAMBARATINSK # 1

ITEM DESCRIPTION	TOTAL COST
General	27,000,000
Common Excavation	721,490
Rock Excavation	22,194,120
Underground Excav.- Tunnels	12,023,200
Underground Excav.- Vertical Tunnels	1,809,500
Backfill	1,029,420
Surface Concrete - M 200 Concrete	16,380,000
Surface Concrete - M 350 Concrete	387,409,000
Surface Concrete - M 400 Concrete	50,336,000
Underground Concrete - M 200 Concrete	19,205,000
Underground Concrete - M 300 Concrete	3,630,000
Consolidation Grout	25,072,500
Grout Curtain	2,325,000
Steel	51,916,160
Mechanical, Electrical,and Other	374,530,000
Gates, Cranes, Etc.	58,422,000
Switchyard	12,000,000
Substation	20,000,000
Transmission Line	264,044,000
Total	1,350,047,390
Contingency	332,114,617
Total w/ Contingency	1,682,162,007
Engineering and Administration	168,216,201
Project cost at March 1993 level	1,850,378,208
All Costs in US Dollars	

K1 ARCH

All Costs In US Dollars

COST ESTIMATE FOR KAMBARATINSK # 1

KYRGYZSTAN LABOR RATES, INTERNATIONAL MATERIAL PRICES AND MODIFIED EQUIPMENT RATES, AT MARCH 1993 LEVEL

CONCRETE ARCH DAM ESTIMATE

Item #	Description		Quantity	Unit	Rate	Total
1	General					
1.1	Mobilization and Demobilization		1	LS	25,000,000	25,000,000
1.2	Access Roads		1	LS	1,000,000	1,000,000
1.3	Housing and Camp		1	LS	1,000,000	1,000,000
						27,000,000
2	Total Excavations & Backfills					
2.1	Common Excavation	Cu M				
2.11	Upstream Cofferdam	13,400				
2.12	Dam Foundations	178,000				
2.13	Powerhouse	75,500				
2.14	Inlet Portal	56,000				
2.15	Outlet Portal	5,000				
2.16	Trans. Line Passage	88,000				
2.17	Other	240,000				
	Total Qty	655,900				
	Total Cost Item 2.1		655,900	Cu M	1.10	721,490
2.2	Rock Excavation	Cu M				
2.21	Water Intake	1,200,000				
2.22	Dam Foundations	2,431,000				
2.23	Powerhouse	954,500				
2.24	Inlet Portal	36,000				
2.25	Outlet Portal	90,000				
2.26	Trans. Line Passage	570,000				
2.27	Other	131,700				
	Total Qty	5,413,200				
	Total Cost Item 2.2		5,413,200	Cu M	4.10	22,194,120

K1 ARCH

All Costs In US Dollars

COST ESTIMATE FOR KAMBARATINSK # 1

KYRGYZSTAN LABOR RATES, INTERNATIONAL MATERIAL PRICES AND MODIFIED EQUIPMENT RATES, AT MARCH 1993 LEVEL

CONCRETE ARCH DAM ESTIMATE

Item #	Description		Quantity	Unit	Rate	Total
2.3	Underground Excav. - Tunnels	Cu M				
2.31	Power Tunnels	101,600				
2.32	Dam	21,000				
2.33	Construction Tunnel	92,100				
	Total Qty	214,700				
	Total Cost Item 2.3		214,700	Cu M	56	12,023,200
2.4	Underground Excav. - Vertical Tunnels	Cu M				
2.41	Vertical Tunneling	23,500				
	Total Qty	23,500				
	Total Cost Item 2.4		23,500	Cu M	77	1,809,500
2.5	Backfill	Cu M				
2.51	Upstream Cofferdams	368,400				
2.52	Downstream Cofferda	30,700				
2.53	Outlet Portal	1,100				
2.54	Others	90,000				
	Total Qty	490,200				
	Total Cost Item 2.5		490,200	Cu M	2.10	1,029,420

K1 ARCH

All Costs In US Dollars

COST ESTIMATE FOR KAMBARATINSK # 1

KYRGYZSTAN LABOR RATES, INTERNATIONAL MATERIAL PRICES AND MODIFIED EQUIPMENT RATES, AT MARCH 1993 LEVEL

CONCRETE ARCH DAM ESTIMATE

Item #	Description		Quantity	Unit	Rate	Total
3	Surface Concrete					
3.1	M 200 Concrete	Cu M				
3.11	Powerhouse	107,000				
3.12	Tailrace	7,000				
3.13	Structures	14,800				
3.14	Dam	15,000				
3.15	Other Areas	20,000				
	Total Qty	163,800				
	Total Cost Item 3.1		163,800	Cu M	100	16,380,000
3.2	M 350 Concrete	Cu M				
3.21	Dam	3,125,000				
3.22	Spillway Passage	301,000				
3.23	Powerhouse	84,800				
3.24	Switchyard	4,800				
3.25	Other	6,300				
	Total Qty	3,521,900				
	Total Cost Item 3.2		3,521,900	Cu M	110	387,409,000
3.3	M 400 Concrete	Cu M				
3.31	Other Reinf. Concrete	186,800				
3.32	Miscellaneous	42,000				
	Total Qty	228,800				
	Total Cost Item 3.3		228,800	Cu M	220	50,336,000

K1 ARCH

All Costs in US Dollars

COST ESTIMATE FOR KAMBARATINSK # 1

KYRGYZSTAN LABOR RATES, INTERNATIONAL MATERIAL PRICES AND MODIFIED EQUIPMENT RATES, AT MARCH 1993 LEVEL

CONCRETE ARCH DAM ESTIMATE

Item #	Description		Quantity	Unit	Rate	Total
4	Underground Concret					
4.1	M 200 Concrete	Cu M				
4.11	Construction Tunnels	17,500				
4.12	Penstocks	43,200				
4.13	Miscellaneous	22,800				
	Total Qty	83,500				
	Total Cost Item 4.1		83,500	Cu M	230	19,205,000
4.2	M 300 Concrete	Cu M				
4.21	Construction Tunnel	11,000				
	Total Qty	11,000				
	Total Cost Item 4.2		11,000	Cu M	330	3,630,000
5	Grout					
5.1	Consolidation Grout	Cu M				
5.11	Construction Tunnel	32,300				
5.12	Spillway Passage	74,000				
5.13	Dam	228,000				
	Total Qty	334,300				
	Total Cost Item 5.1		334,300	Cu M	75	25,072,500
5.2	Grout Curtain	Cu M				
5.21	Construction Tunnel	1,000				
5.22	Dam	30,000				
	Total Qty	31,000				
	Total Cost Item 5.2		31,000	Cu M	75	2,325,000

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K1 ARCH

All Costs in US Dollars

COST ESTIMATE FOR KAMBARATINSK # 1

KYRGYZSTAN LABOR RATES, INTERNATIONAL MATERIAL PRICES AND MODIFIED EQUIPMENT RATES, AT MARCH 1993 LEVEL

CONCRETE ARCH DAM ESTIMATE

Item #	Description	Quantity	Unit	Rate	Total
6	Steel				
6.1	Penstock Steel Liner	12,700	Tonne	2,062	26,187,400
6.2	Structural Steel	10,400	Tonne	2,106	21,902,400
6.3	Rockbolts	1,156	Tonne	3,310	3,826,360
	Total Cost Item 3.1				51,916,160
7	Mechanical, Electrical, and Other				
7.1	Francis Units 485 MW	4	Ea	42,180,000	168,720,000
7.2	Transformers	4	Ea	7,760,000	31,040,000
7.3	Generators	4	Ea	38,800,000	155,200,000
7.4	Miscellaneous Mech.	1	LS	13,750,000	13,750,000
7.5	Miscellaneous Elec.	1	LS	5,820,000	5,820,000
	Total Cost Item 6				374,530,000

K1 ARCH

All Costs in US Dollars

COST ESTIMATE FOR KAMBARATINSK # 1

KYRGYZSTAN LABOR RATES, INTERNATIONAL MATERIAL PRICES AND MODIFIED EQUIPMENT RATES, AT MARCH 1993 LEVEL

CONCRETE ARCH DAM ESTIMATE

Item #	Description	Quantity	Unit	Rate	Total
8	Gates, Cranes, Etc.				
8.1	Gates, Hoists, Etc.	1	LS	47,907,000	47,907,000
8.2	Cranes	1	LS	10,515,000	10,515,000
	Total Cost Item 7				58,422,000
9	Switchyard	1	LS	12,000,000	12,000,000
10	Substation	1	LS	20,000,000	20,000,000
11	Transmission 500 kV	706	Km	374,000	264,044,000
					1,350,047,390
	Contingency, Civil Work	30%			186,315,417
	Contingency, All Other Work	20%			145,799,200
					1,682,162,007
	Engineering and Administration	10%			168,216,201
	Total Cost @ March 1993 Level				1,850,378,208

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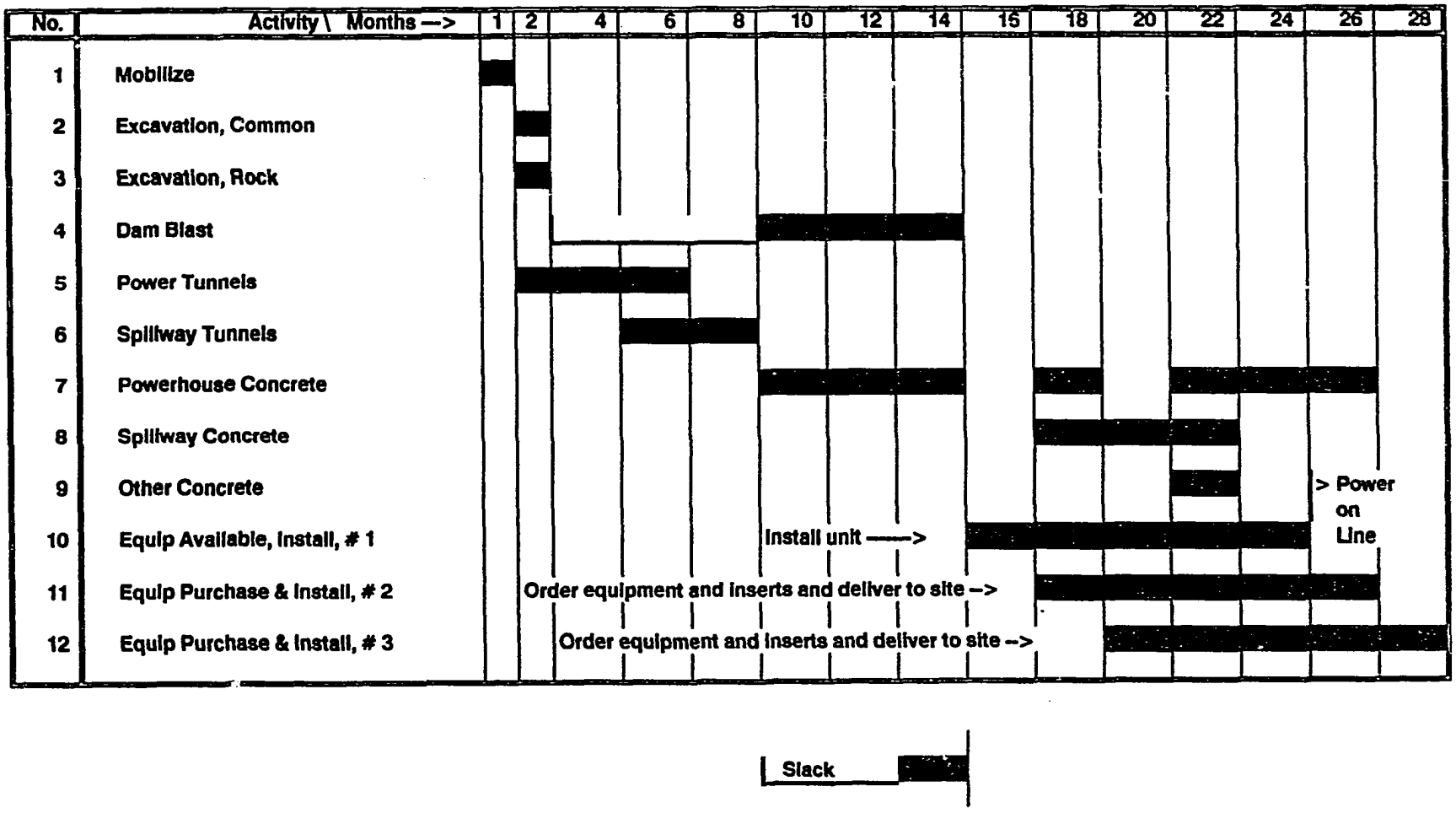
KAMBARATINSK 2 BLAST DAM SCHEDULE

CONSTRUCTION SCHEDULE FOR KAMBARATINSK 2 HYDRO PROJECT IN KYRGYZSTAN



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K2 "BLAST" FILL DAM All Costs in US Dollars

COST ESTIMATE FOR KAMBARATINSK # 2

ITEM DESCRIPTION	TOTAL COST
General Items	1,700,000
Common Excavation	585,035
Rock Excavation	13,120
Tunneling	8,601,600
Backfill	1,064,910
Wet Blanket	800,000
Underground Concrete	31,740,000
Surface Concrete	28,935,000
Consolidation Grout	2,088,000
Contact Grout	1,073,600
Shotcrete	112,500
Steel	16,504,076
Blast Material	3,587,500
Blast Tunnels	0
Mech/Elec/Other	69,030,000
Switchyard	6,000,000
Transmission Line	17,578,000
Total	189,413,341
Total Contingency	47,563,202
Total with Contingency	236,976,543
Engineering & Administration	23,697,654
Project cost at March 1993 level	260,674,197
All Costs in US Dollars	

K2 "BLAST" FILL DAM

All Costs in US Dollars

COST ESTIMATE FOR KAMBARATINSK # 2

KYRGYZSTAN LABOR RATES, INTERNATIONAL MATERIAL PRICES AND MODIFIED EQUIPMENT RATES, AT MARCH 1993 LEVEL

"BLAST" FILL DAM ESTIMATE

Item #	Description		Quantity	Unit	Rate	Total
1	General Items					
1.1	Mobilization and Demobilization		1	LS	1,500,000	1,500,000
1.2	Access Roads		1	LS	100,000	100,000
1.3	Housing and Camp		1	LS	100,000	100,000
	Total Cost Item 1					1,700,000
2	Total Excavations and Backfills					
2.1	Common Excavation	Cu M				
2.11	Intake Channel	50,000				
2.12	Tailrace	55,000				
2.13	Cable Gallery and Irrigation Release	18,850				
2.14	Spillway Tunnel	90,000				
2.15	Powerhouse Platform	318,000				
	Total Qty	531,850				
	Total Cost Item 2.1		531,850	Cu M	1.10	585,035
2.2	Rock Excavation	Cu M				
2.21	Irrigation Release	1,500				
2.22	Miscellaneous	1,700				
	Total Qty	3,200				
	Total Cost Item 2.2		3,200	Cu M	4.10	13,120

K2 "BLAST" FILL DAM

All Costs In US Dollars

COST ESTIMATE FOR KAMBARATINSK # 2

KYRGYZSTAN LABOR RATES, INTERNATIONAL MATERIAL PRICES AND MODIFIED EQUIPMENT RATES, AT MARCH 1993 LEVEL

"BLAST" FILL DAM ESTIMATE

Item #	Description		Quantity	Unit	Rate	Total
2.3	Tunneling	Cu M				
2.31	Spillway Tunnel	41,600				
2.32	Power and Draft Tube Tunnels	112,000				
	Total Qty	153,600				
	Total Cost Item 2.3		153,600	Cu M	56	8,601,600
2.4	Backfill	Cu M				
2.41	Intake	55,000				
2.42	Tailrace	129,000				
2.43	Powerhouse Platform	189,000				
2.44	Switchyard	94,100				
2.45	Cable Gallery and Misc.	40,000				
	Total Qty	507,100				
	Total Cost Item 2.4		507,100	Cu M	2.10	1,064,910
2.5	Wet Blanket	250,000				
	Total Cost Item 2.5		250,000	Cu M	3.20	800,000
3	Underground Concrete	Cu M				
3.1	Power Tunnel	70,400				
3.2	Spillway tunnel	37,400				
3.3	Irrigation Release and Misc.	30,200				
	Total Qty	138,000				
	Total Cost Item 3		138,000	Cu M	230	31,740,000

K2 "BLAST" FILL DAM All Costs In US Dollars

COST ESTIMATE FOR KAMBARATINSK # 2

KYRGYZSTAN LABOR RATES, INTERNATIONAL MATERIAL PRICES AND MODIFIED EQUIPMENT RATES, AT MARCH 1993 LEVEL

"BLAST" FILL DAM ESTIMATE

Item #	Description		Quantity	Unit	Rate	Total
4	Surface Concrete (All Reinforced)	Cu M				
4.1	Powerhouse	84,900				
4.2	Tailrace	17,800				
4.3	Spillway Tunnel	21,600				
4.4	Intake Concrete	38,100				
4.5	Powerhouse Platform	4,675				
4.6	Irrigation Release and Substation	5,900				
4.7	Tunnels & Galleries	18,600				
4.8	Miscellaneous	1,325				
	Total Qty	192,900				
	Total Cost Item 4		192,900	Cu M	150	28,935,000
5	Grout					
5.1	Consolidation Grout	Sq M				
5.11	Tunnels & Galleries	60,100				
5.12	Spillway Tunnel	8,500				
5.13	Miscellaneous	1,000				
	Total Qty	69,600				
	Total Cost Item 5.1		69,600	Sq M	30	2,088,000
5.2	Contact Grout	Sq M				
5.21	Tunnels & Galleries	101,100				
5.22	Spillway Tunnel	30,100				
5.23	Miscellaneous	3,000				
	Total Qty	134,200				
	Total Cost Item 5.2		134,200	Sq M	8.00	1,073,600
5.3	Shotcrete	3,750				
	Total Cost Item 5.3		3,750	Sq M	30	112,500

K2 "BLAST" FILL DAM All Costs In US Dollars

COST ESTIMATE FOR KAMBARATINSK # 2

KYRGYZSTAN LABOR RATES, INTERNATIONAL MATERIAL PRICES AND MODIFIED EQUIPMENT RATES, AT MARCH 1993 LEVEL

"BLAST" FILL DAM ESTIMATE

Item #	Description	Quantity	Unit	Rate	Total
6	Steel				
6.1	Penstock Steel Liner	5,510	Tonne	2,062	11,361,620
6.2	Structural Steel	300	Tonne	2,106	631,800
6.3	Rockbolts	786	Tonne	3,310	2,601,660
6.4	Steel Sets	66	Tonne	2,106	138,996
6.5	Galvanized Steel	590	Tonne	3,000	1,770,000
	Total Cost Item 6				16,504,076
7	Blasting Material - Explosives				
	Total Cost Item 7	2,870	Tonne	1,250	3,587,500
8	Underground Excavation for "Blast" Dam				
8.1	Vertical Silos	Completed			
8.2	Lateral Galleries	Completed			
	Total Cost Item 8				0
9	Mechanical, Electrical, and Other				
9.1	Francis Units 2 x 120 MW	2	Ea	8,767,000	17,534,000
9.2	Transformers	2	Ea	1,200,000	2,400,000
9.3	Generators	2	Ea	9,600,000	19,200,000
9.4	Miscellaneous Mech.	1	LS	11,600,000	11,600,000
9.5	Miscellaneous Elec.	1	LS	2,160,000	2,160,000
9.6	Gates, Hoists, Etc.	1	LS	12,836,000	12,836,000
9.7	Arch. Finishing	1	LS	3,300,000	3,300,000
	Total Cost Item 9				69,030,000

K2 "BLAST" FILL DAM All Costs In US Dollars

COST ESTIMATE FOR KAMBARATINSK # 2

KYRGYZSTAN LABOR RATES, INTERNATIONAL MATERIAL PRICES AND MODIFIED EQUIPMENT RATES, AT MARCH 1993 LEVEL

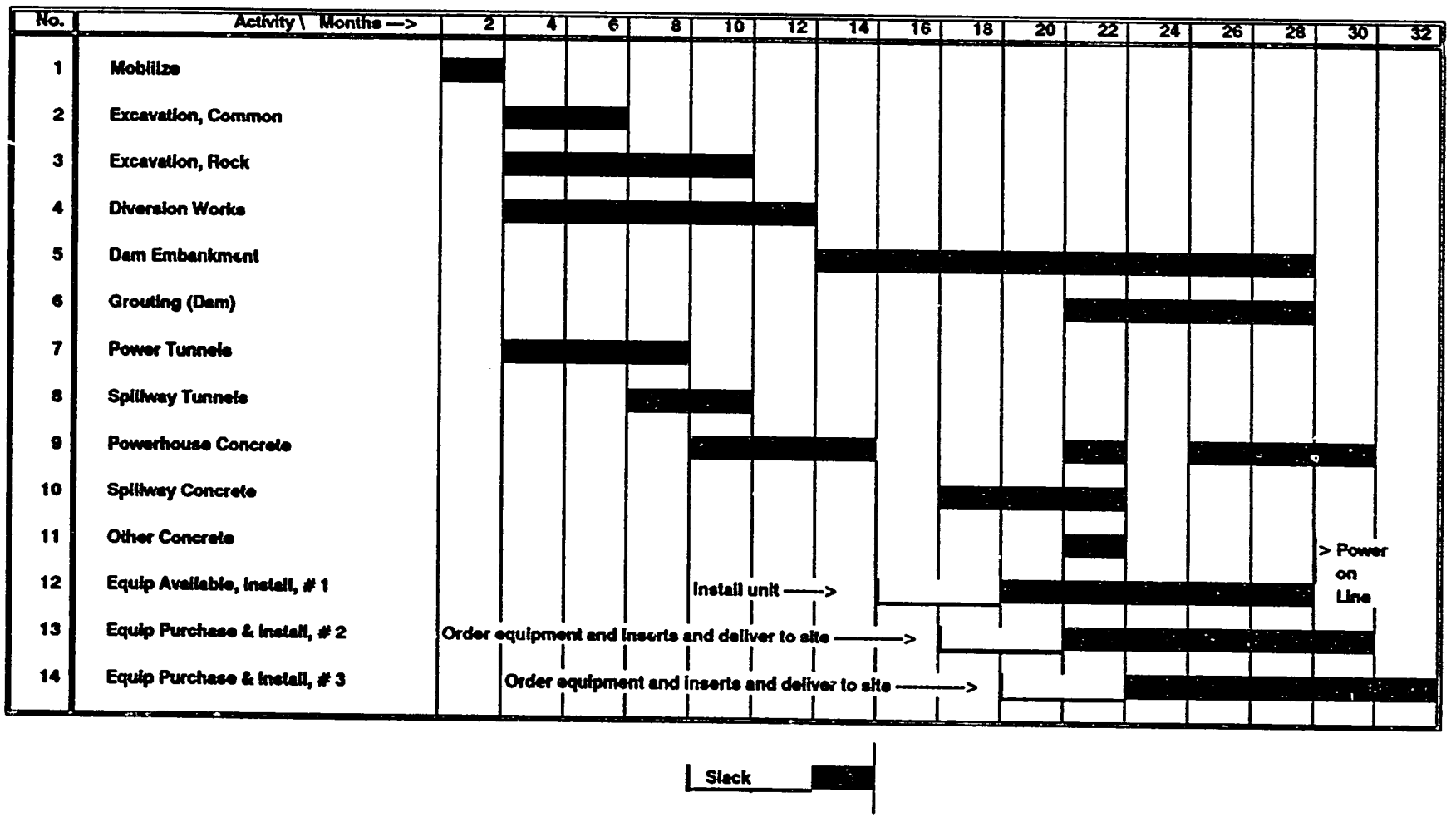
"BLAST" FILL DAM ESTIMATE

Item #	Description	Quantity	Unit	Rate	Total
10	Switchyard	1	LS	6,000,000	6,000,000
11	Transmission 500kV	47	Km	374,000	17,578,000
					189,413,341
	Contingency, Civil work	30%			29,041,602
	Contingency, All other work	20%			18,521,600
					236,976,543
	Engineering and Administration	10%			23,697,654
	Total Cost at March 1993 Level				260,674,197

25-Aug-93

KAMBARATINSK 2 RANDOM FILL DAM SCHEDULE

CONSTRUCTION SCHEDULE FOR KAMBARATINSK 2 HYDRO PROJECT IN KYRGYZSTAN



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K2 RANDOM FILL DAM All Costs in US Dollars

COST ESTIMATE FOR KAMBARATINSK # 2

ITEM DESCRIPTION	TOTAL COST
General Items	3,400,000
Common Excavation	591,635
Rock Excavation	50,430
Tunneling	12,056,800
Dam Embankment	4,406,400
Backfill	1,064,910
Underground Concrete	36,294,000
Surface Concrete	29,835,000
Consolidation Grout	4,599,000
Contact Grout	1,265,600
Shotcrete	112,500
Steel	16,562,001
Concrete Plug Blast Tunnels	714,000
Mech/Elec/Other	69,030,000
Switchyard	6,000,000
Transmission Line	17,578,000
Total	203,560,276
Contingency	51,807,283
Total with Contingency	255,367,559
Engineering & Administration	25,536,756
Project Cost at March 1993 Level	280,904,315
All Costs in US Dollars	

K2 FILL DAM

All Costs in US Dollars

COST ESTIMATE FOR KAMBARATINSK # 2

KYRGYZSTAN LABOR RATES, INTERNATIONAL MATERIAL PRICES AND MODIFIED EQUIPMENT RATES, AT MARCH 1993 LEVEL

RANDOM FILL DAM ESTIMATE

Item #	Description		Quantity	Unit	Rate	Total
1	General Items					
1.1	Mobilization and Demobilization		1	LS	3,000,000	3,000,000
1.2	Access Roads		1	LS	200,000	200,000
1.3	Housing and camp		1	LS	200,000	200,000
	Total Cost Item 1					3,400,000
2	Total Excavations and Backfill					
2.1	Common Excavation	Cu M				
2.11	Intake Channel	50,000				
2.12	Tailrace	55,000				
2.13	Cable Gallery & Irrigation Release	18,850				
2.14	Spillway Tunnel	90,000				
2.15	Powerhouse Platform	318,000				
2.16	Div. Tun. Portal	6,000				
	Total Qty	537,850				
	Total Cost Item 2.1		537,850	Cu M	1.10	591,635
2.2	Rock Exacavtion	Cu M				
2.21	Dam	9,100				
2.22	Irrigation Release	1,500				
2.23	Miscellaneous	1,700				
	Total Qty	12,300				
	Total Cost Item 2.2		12,300	Cu M	4.10	50,430

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K2 FILL DAM

All Costs in US Dollars

COST ESTIMATE FOR KAMBARATINSK # 2

KYRGYZSTAN LABOR RATES, INTERNATIONAL MATERIAL PRICES AND MODIFIED EQUIPMENT RATES, AT MARCH 1993 LEVEL

RANDOM FILL DAM ESTIMATE

Item #	Description		Quantity	Unit	Rate	Total
2.3	Tunneling	Cu M				
2.31	Spillway Tunnel	41,600				
2.32	Power and DT Tunnels	112,000				
2.33	Dam	4,000				
2.34	Diversion Tunnel	57,700				
	Total Qty	215,300				
	Total Cost Item 2.3		215,300	Cu M	56	12,056,800
2.4	Dam	Cu M				
2.41	Sand	43,000				
2.42	Gravel	105,000				
2.43	Random	1,148,000				
	Total Qty	1,296,000				
	Total Cost Item 2.4		1,296,000	Cu M	3.40	4,406,400
2.5	Backfill	Cu M				
2.51	Intake	55,000				
2.52	Tailrace	129,000				
2.53	Powerhouse Platform	189,000				
2.54	Switchyard	94,100				
2.55	Cable Gal. & Misc.	40,000				
	Total Qty	507,100				
	Total Cost Item 2.5		507,100	Cu M	2.10	1,064,910

TP

K2 FILL DAM

All Costs In US Dollars

COST ESTIMATE FOR KAMBARATINSK # 2

KYRGYZSTAN LABOR RATES, INTERNATIONAL MATERIAL PRICES AND MODIFIED EQUIPMENT RATES, AT MARCH 1993 LEVEL

RANDOM FILL DAM ESTIMATE

Item #	Description		Quantity	Unit	Rate	Total
3	Underground Concrete (All Reinforced)	Cu M				
3.1	Power Tunnel	70,400				
3.2	Spillway Tunnel	37,400				
3.3	Irrigation Release & Misc.	30,200				
3.4	Diversion Tunnel	15,300				
3.5	Div. Tun. Plug	4,500				
	Total Qty	157,800				
	Total Cost Item 3		157,800	Cu M	230	36,294,000
4	Surface Concrete (All Reinforced)	Cu M				
4.1	Powerhouse	84,900				
4.2	Tailrace	17,800				
4.3	Spillway Tunnel	21,600				
4.4	Intake Concrete	38,100				
4.5	Powerhouse Platform	4,675				
4.6	Irrigation Release & Substation	5,900				
4.7	Portal Concrete	6,000				
4.8	Tunnels & Galleries	18,600				
4.9	Miscellaneous	1,325				
	Total Qty	198,900				
	Total Cost Item 4		198,900	Cu M	150	29,835,000

K2 FILL DAM

All Costs In US Dollars

COST ESTIMATE FOR KAMBARATINSK # 2

KYRGYZSTAN LABOR RATES, INTERNATIONAL MATERIAL PRICES AND MODIFIED EQUIPMENT RATES, AT MARCH 1993 LEVEL

RANDOM FILL DAM ESTIMATE

Item #	Description		Quantity	Unit	Rate	Total
5	Grout					
5.1	Consolidation Grout	Sq M				
5.11	Tunnels & Galleries	60,100				
5.12	Spillway Tunnel	8,500				
5.13	Diversion	21,500				
5.14	Dam	60,000				
5.15	Concrete Plug	2,200				
5.16	Miscellaneous	1,000				
	Total Qty	153,300				
	Total Cost Item 5.1		153,300	Sq M	30	4,599,000
5.2	Contact Grout	Sq M				
5.21	Tunnels & Galleries	101,100				
5.22	Spillway Tunnel & Outlet	30,100				
5.23	Dam	24,000				
5.24	Miscellaneous	3,000				
	Total Qty	158,200				
	Total Cost Item 5.2		158,200	Sq M	8.00	1,265,600
5.3	Shotcrete	3,750				
	Total Cost Item 5.3		3,750	Sq M	30	112,500

K2 FILL DAM

All Costs In US Dollars

COST ESTIMATE FOR KAMBARATINSK # 2

KYRGYZSTAN LABOR RATES, INTERNATIONAL MATERIAL PRICES AND MODIFIED EQUIPMENT RATES, AT MARCH 1993 LEVEL

RANDOM FILL DAM ESTIMATE

Item #	Description	Quantity	Unit	Rate	Total
6	Steel				
6.1	Penstock Steel Liner	5,510	Tonne	2,062	11,361,620
6.2	Structural Steel	300	Tonne	2,106	631,800
6.3	Rockbolts @ Div. Tun.	17.5	Tonne	3,310	57,925
6.4	Rockbolts	786	Tonne	3,310	2,601,660
6.5	Steel Sets	66	Tonne	2,106	138,996
6.6	Galvanized Steel	590	Tonne	3,000	1,770,000
	Total Cost Item 6				16,562,001
7	Concrete Plug Underground Excavation for "Blast" Dam	Cu M			
7.1	Blast Chamber	3,700	Cu M		
7.2	Access Galleries	4,700	Cu M		
	Total Qty	8,400	Cu M		
	Total Cost Item 7			85	714,000
8	Mechanical, Electrical, and Other				
8.1	Francis Units 2 x 120 MW	2	Ea	8,767,000	17,534,000
8.2	Transformers	2	Ea	1,200,000	2,400,000
8.3	Generators	2	Ea	9,600,000	19,200,000
8.4	Miscellaneous Mech	1	LS	11,600,000	11,600,000
8.5	Miscellaneous Elec	1	LS	2,160,000	2,160,000
8.6	Gates, hoists, etc.	1	LS	12,836,000	12,836,000
8.7	Arch. Finishing	1	LS	3,300,000	3,300,000
	Total Cost Item 8				69,030,000

K2 FILL DAM

All Costs In US Dollars

COST ESTIMATE FOR KAMBARATINSK # 2

KYRGYZSTAN LABOR RATES, INTERNATIONAL MATERIAL PRICES AND MODIFIED EQUIPMENT RATES, AT MARCH 1993 LEVEL

RANDOM FILL DAM ESTIMATE

Item #	Description	Quantity	Unit	Rate	Total
9	Switchyard	1	LS	6,000,000	6,000,000
10	Transmission 500kV	47	Km	374,000	17,578,000
					203,560,276
	Contingency, Civil work	30%			33,285,683
	Contingency, All other work	20%			18,521,600
					255,367,559
	Engineering and Administration	10%			25,536,756
	Total cost @ March 1993 Level				280,904,315

Chapter 6

THE UPPER NARYN HYDROELECTRIC PROJECTS

6.1 The Proposed Development

The Upper Naryn hydroelectric potential was investigated by the Tashkent Hydro Design Institute (THDI) specialists in 1990. Eight sites were inventoried (reconnaissance study level) then on both Naryn and Small Naryn rivers. One of them, the Naryn 1 Hydroelectric Plant, was developed at the feasibility level (Technic and Economic Calculations) in 1992. A general location map of the Upper Naryn developments is presented on Exhibit 3-1. Table 6-1 presents the main characteristics of the eight powerplants.

Table 6-1

UPPER NARYN HYDROELECTRIC PROJECTS

Project Name	Proj. Type	Design Net H (m)	Design Disch. (m^3/s)	Instal. Capacity (MW)	Depend. Capac. (MW)	Annual En.Prod. (GWh/yr)
Oruktam 1	RES	97.0	70.0	60.0	40.0	254.3
Oruktam 2	DIV	112.4	50.0	48.0	43.3	259.0
Echinaryn	DIV	21.6	50.0	9.5	8.4	49.7
Dzhanykel	RES	141.0	109.0	130.0	48.0	470.0
Akbulunsk	ROR	74.0	157.0	100.0	24.0	372.0
Naryn 1	DIV	45.0	157.0	62.0	14.0	227.0
Naryn 2	DIV	43.4	160.0	60.0	15.0	235.0
Naryn 3	DIV	50.0	160.0	60.0	17.0	254.0
TOTAL	n/a	n/a	n/a	408.5	307.8	2054.0

Notations : RES = Storage project
ROR = Run of river
DIV = Diversion project (canal or tunnel)

The data shown in Table 6-1 reflect the whole Upper Naryn development. It is based on pre-feasibility level concepts, except for the Naryn 1 powerplant where a feasibility level study was performed. Also, the installed capacity of both the Naryn 2 and 3 projects were increased to 60 MW from the pre-feasibility estimate of 38 and 48 MW respectively, based on the results of the feasibility study of Naryn 1.

The Harza team visited the sites area and reviewed the scheme elements. The total scheme described is a model of how the hydroelectric potential of a mountainous river should be developed at the headwaters. The Upper Naryn presents a rich potential, with large mountain streams (mean annual flows between 35 and 85 m^3/s) flowing in relatively steep valleys (slopes between 0.7 and 1.7 percent). The project configurations selected are correct and based on a string of sound design criteria :

- Whenever a narrows was following a significant valley enlargement characterized by a flat slope, a dam site was selected; this is the case with Oruktam 1 and Dzhanykel;

- The continuous steep slopes were developed by diversion projects in cascade; diversions were mostly canals (total length of 23.5 km), located in the generally wide floodplain; the weir type control structures were maintained at the river bank level in order to protect valley settlements and a major highway from flooding; this is the case with the three Naryn projects located downstream of the confluence between Naryn and Small Naryn rivers;

- Reaches with very steep slopes and continuous narrow valleys were developed by incorporating underground diversion works; this is the case with Oruktam 2, whose scheme includes a 8.15 km tunnel and a 135 m shaft.

In this chapter, a description of each project is provided, based on the information available. Typical layouts for the Dzhanykel and Naryn No. 1 projects are presented as examples of storage and run-of-river projects as investigated by the THDI engineers.

6.2 Project Setting

6.2.1 Location

The Upper Naryn Cascade Hydroelectric Projects include up to eight hydroelectric stations. The stations will be located in the upper reaches of the Naryn River in the vicinity of the confluence of the two branches of the Naryn River, eastern Kyrgyzstan (see Exhibit 3-1).

6.2.2 Topographic Mapping

Topographic and geodesic work was completed for the Upper Naryn Cascade as a part of the Alabugin Technical/Economic Feasibility Study (THDI, Report No. 1328-T3, 1990). Topographic maps were produced at a scale of 1:2000. Nineteen hydraulic cross sections were surveyed along the Naryn River.

6.2.3 Geologic and Geotechnical Investigations

Geologic and geotechnical investigations of the Upper Naryn Cascade were studied as a part of the general technical and economical investigation study which was conducted for the proposed downstream Alabugin Hydroelectric Station (THDI, Report No. 1328-T4, 1990). Geologic maps and sections were bound in a separate document (Report No. 1328-P3, 1990). A discussion of the engineering geologic conditions of the Naryn No. 1 site is included in the Naryn No. 1 Technical Feasibility Study (Report No. 1389-T3).

Naryn No. 1 is located in the Central Tian Shan part of Kyrgyzstan. The Huratau range is located toward the North and the Naryn Too range in the South. The valley bottom bedrock is metamorphosed and deformed PreCambrian and Paleozoic rock. The lower valley bottom is covered with a layer of red and gray Cenezoic sediments which has been displaced during tectonic movements.

Cambrian rocks are quartz-chlorite-serecite schists, slates and conglomerates. Cenozoic sediments are located along both banks of the Naryn and include clays with sand lenses. Younger Cenezoic rocks include gypsum, conglomerates, and sandstones.

Landslides and debris slides occur frequently along the banks of the Naryn River.

The Kyrgyz Academy of Sciences Seismology Institute recommends that the structures be designed for seismicity of 9 points.

The yearly suspended sediment flow is about 25 kg per second or 790,000 tons per year.

6.2.4 Hydrology

The drainage basin area is 9589 km^2. The basin is bordered by the Borkoldoi, the Naryn Too, the Terskey-Ala Too, and the Akshirak mountain ranges. The mountains have peeks up to 5100 meters high. Glaciers comprise 33 percent of the drainage basin area.

The average annual flow of the Naryn River at the Naryn No. 1 site for the period 1910/11 to 1990/91 is 75.7 m^3/s. The annual flow variation coefficient is 0.21. During the peak run-off period, April to September, the average flow is 127 m^3/s. The maximum average monthly flow is 200 m^3/s in July and the minimum is 18.9 m^3/s in February.

6.3 Dzhanykel Hydroelectric Station Description

This project represents the only significant storage proposed on the Big Naryn river. The layout proposed by the THDI specialists at the pre feasibility level includes a relatively high dam, an intake structure, power and spillway tunnels, powerhouse, tailrace, and switchyard. The proposed layout components (plan views and sections) are presented on Drawings UN-03.

6.3.1 Dam

The dam included in the configuration is a 160 m-high random fill (sand and pebble) structure, rock riprap-protected on both upstream and downstream faces, with a central asphaltic membrane protected into the alluvium foundation and surrounded by a filter material. A 60 m-deep grout curtain is provided below the membrane. The total dam material volume amounts to 4,860,000 m^3 and the live volume of the reservoir is 325 million m^3 (normal maximum operating level in the dam forebay is at elevation 2500.0 m).

6.3.2 Intake, Spillway and Power Tunnels, and Penstock

A common intake structure located on the left bank is provided with unequal openings to divert water to both power and spillway tunnels, depending on the magnitude of the river flow. Both power and spillway tunnels are horseshoe shaped, lined with reinforced concrete and grouted behind the liner. The 650 m-long spillway tunnel has a 7.5 m I.D. and discharges floods into the Naryn through an energy dissipating structure. The 915 m-long power tunnel has a 5.0 m I.D. and conveys the power discharge into a concrete-backfilled steel penstock which includes a 110 m-deep vertical shaft and a 200 m-long horizontal reach to the wye distributor (3.5 m I.D.).

6.3.3 Powerhouse

The distributor feeds an indoor, surface, 2-unit powerhouse with short tailrace canal. The normalized turbines are of the type RO 230/821 b-V-260. Normal tailwater is at elevation 2315 m. Design head is 141 m and design discharge amounts to 54.5 cms per unit. Two

SV-591/179-20 generators and two transformers are included in the configuration. The installed capacity of the plant amounts to 130 MW and the average energy production, to 470 GWh/yr.

6.3.4 Switchyard

The outdoor switchyard located on the left bank close to the powerhouse a total area of 250 X 150 m.

6.3.5 Transmission Interconnection

The project would be interconnected to a new 220-kV transmission line which would be routed along the Naryn river. The cost of a 30-km, 220-kV line has been included in the construction cost estimate.

6.3.6 Access Road

The same two-lane, hard cover road which passes by the Naryn 1, 2, and 3 plants reaches the Dzhanykel site and is used for transit to several communities in the area

6.3.7 Construction Cost Estimate

Chapter 4 describes the approach and methodology used to prepare the cost estimates. The chapter details the bases for labor, materials and construction equipment rates, unit prices, direct and indirect costs, contingencies and total construction cost. A general description of the cost analysis for the major cost items is also presented.

Total construction cost for the Dzhanykel project is estimated at $ 176.5 million at a March 1993 price level. Table 6-2 shows the estimated construction cost of the project by major item. The detailed cost estimate is presented in Exhibit 6-1.

Table 6-2

DZHANYKEL COST ESTIMATE

Item Description		Total in $$
General Items		5,900,000
Common Excavation		310,300
Rock Excavation		1,069,280
Underground Exc. - Tunnels		10,192,000
Underground Exc. - Vert. Tunnels		860,000
Dam Embankment		16,329,600
Backfill		98,280
Surface Concrete - M 200		9,544,500
Surface Concrete - M 300		12,078,000
Underground Concrete		7,282,000
Consolidation Grout		5,557,500
Core Grouting (in Dam)		600,000
Shotcrete		750,000
Steel		6,926,590
Mechanical, Electrical, Other		25,553,750
Gates, Cranes, Etc.		15,591,000
Switchyard		1,000,000
Transmission Line		7,620,000
Direct cost Total		127,262,800
Contingency		33,202,365
Subtotal		160,465,165
Engineering and Administration 10%		16,046,517
Project cost total at March 1993 level	**U.S. $**	**176,511,682**

6.4 Naryn No. 1 Hydroelectric Station Description

The Naryn No. 1 Project developed at feasibility level and presented here is a typical diversion project as implemented in the Upper Naryn. The layout proposed by the THDI specialists consists of a combined fill and a gated weir dam (barrage), a power intake leading into a power diversion canal, a forebay as a penstock intake, four steel penstocks, an indoor, surface, 4-unit powerhouse with tailrace canal, and outdoors switchyard. The installed capacity of the plant amounts to 62 MW (maximum net head of 47 m, 4-unit discharge of 157 m^3/s). The average energy production is 227 GWh/yr. Design head is 45 m. The proposed layout components (plan views and sections) are presented on Drawings UN-01 and UN-02.

6.4.1 Dam and Spillway

Naryn No. 1 normal headwater level is 2235 meters. Normal tailwater is 2188.1 meters, which is also the normal headwater level for Naryn No. 2 powerplant. The dam is a 245,000 m^3 random material fill (sand and pebble), protected by 1:2.4 (us.) and 1:2.5 (ds.) rock slopes. The impervious central core is built from a compacted clay and sand mixture with maximum size of 200 mm, grouted over all the height and deep into the alluvial foundation. Upstream and downstream rock cofferdams, 5.5 and 7.5 m tall respectively and incorporated into the dam final profile, are built in the beginning for water control during construction. River flows are diverted through a temporary canal excavated on the left bank.

River floods during plant operation are controlled by a low weir with five 5.0 x 6.0 m openings controlled by hydraulic hoist-operated slide emergency gates. Upstream these gates, two additional sets of slots are provided for repairs/maintenance gates and for maintenance bulkheads. The ogee is at elevation 2220.0 m, only 5 m above the river bed. Weir foundation is excavated 8 m in alluvium to the bedrock located at elevation 2209.0 m. The gated weir is built in the river bed over a total width of 41.5 m and connecting the fill dam to the power intake. The gated weir structure ends with a reinforced concrete energy dissipation basin 50 m-long, 5 m-deep and 41.5 m-wide. The basin is connected to the river bed by a riprap protected apron. Weir spillway capacity with gates fully raised corresponds to the 10000-yr flood peak of 1532 m^3/s which passes almost flush through the openings and flows at elevation 2224.5 m through the dissipation basin and tailrace. Maximum normal operating elevation in the dam/weir forebay is 2235.0 m, which is also the maximum water surface corresponding to the design flood peak passage as controlled by the weir.

6.4.2 Power Intake, Forebay and Penstocks

The power intake is a reinforced concrete structure adjacent to the weir and erected on the left bank of the river. It consists of two 5.0 x 4.5 m openings controlled by gates operated by hydraulic hoists. Upstream and downstream these gates, slots are provided for maintenance bulkheads and gates respectively.

The intake leads power discharges through a 5.7 km-long, practically horizontal power canal, to the penstock intake (canal inlet invert is at elevation 2228.5 m and outlet invert is at 2227.5 m, dropping only 1 m over the total length). The 7.3 m-high trapezoidal canal is mostly excavated in the left bank sedimentary deposits, although the right bank is occasionally a partial fill. Only about 150 m of canal are completely built by fill. Side slopes are 1:1.5 and the top width of the waterway amounts to 30 m. Whether in excavation or fill, the canal sides and bottom are lined with 20 cm of concrete, placed over 10 cm of equalizing gravel. A 7 m-wide maintenance road representing the right embankment top is built parallel to the canal. The left embankment top width varies between 3 and 7 m, depending on the proximity of the valley slope. Three cross drainage structures with reinforced concrete open culvert configurations (one or two paths), are built at tributary crossings. Their total length amounts to about 300 m.

The power conveyance discharges into a 30 m-wide, 30 m-long, 12 m-deep reinforced concrete penstock forebay that includes an intake structure with four openings at the downstream end. The intake is controlled by repair-maintenance slide gates operated by hydraulic hoists. Upstream the gates location, trash racks and slots for maintenance bulkheads are provided. Invert at the intake is at elevation 2223.6. Four steel penstocks, two with 4.2 m I.D. and two with 2.4 m I.D., convey the water over a 40 m vertical drop under a slope of about 1V:2.5H. Penstock are exposed and supported by a reinforced concrete sloped slab, down to the powerhouse. Penstocks are about 110 m-long and are anchored into the slab by ring girders every 15 m.

6.4.3 Powerhouse

The indoor, surface powerhouse is a 68 m-long (including erection bay), 33 m-wide (including draft tube deck), structure located on the left bank of Naryn. Pit excavation is some 20 m into the defluvium, to elevation 2176 m. It has four unequal units. Two 7.25 MW, RO 75/728b-V-160 normalized units occupy the smaller bays and are to be installed under an open flume arrangement. Design discharge is 17.7 m^3/s per unit which rotates at 300 rpm. Runner diameter is 1.6 m. The two generators type SV 325/73-20 UHL4 are rated at 7 MW (8.75 MVA), 0.8 cos fi, 6.3 kV, 300 rpm.

The two larger RO 75/728b-B-280 normalized turbines will be installed in a conventional draft tube configuration. Design discharge is 60.9 m^3/s per unit which rotates at 187.5 rpm. Runner diameter is 2.8 m. Net design head is 45 m for both type of units and unit centerline is the same at elevation 2185.2 m. The two larger generators of type SV 550/134-32 UHLA are rated at 24 MW (30 MVA), 0.8 cos fi, 6.3 kV, 187.5 rpm.

Two transformers TD 40000/220 rated 40 MVA, 242/6.3 kV, are installed on the powerhouse downstream deck at elevation 2195.35 (same as generator floor).

The draft tubes and the flumes are controlled by gates of different sizes operated by the same crane installed at elevation 2195.35 m. Discharge is returned to the river through a 380 m-long tailrace canal. Normal tailwater is at elevation 2188.1 m and plant design flood peak (1532 m^3/s) elevation at the discharge point is at elevation 2190.1 m.

6.4.4 Switchyard

The 120 m x 100 m outdoors 220 kV switchyard is located also on the left bank of the river, at elevation 2207.0 m. The construction is part excavation, part fill (about half-half). The platform is connected to the transformer deck by 80-m-long aerial cables.

6.4.5 Transmission Interconnection

The project would be interconnected to a new 220-kV transmission line which would be routed along the Naryn river. The cost of a 25-km, 220-kV line has been included in the construction cost estimate.

6.4.6 Access Road

A two-lane, hard cover road transitable by heavy trucks and other construction equipment, as well as by city vehicles, is in operation presently, being used for transit to the city of Naryn and to other communities in the area. No portions of this road will have to be relocated to accommodate the construction of the Naryn No.1 power station.

6.4.7 Construction Cost Estimate

Chapter 4 describes the approach and methodology used to prepare the cost estimates. The chapter details the bases for labor, materials and construction equipment rates, unit prices,

direct and indirect costs, contingencies and total construction cost. A general description of the cost analysis for the major cost items is also presented.

Total construction cost for the Naryn 1 project is estimated at $ 96.8 million at a March 1993 price level. Table 6-3 shows the estimated construction cost of the project by major item. The detailed cost estimate is presented in Exhibit 6-2.

Table 6-3

NARYN 1 COST ESTIMATE

Item Description		Total in $$
General Items		5,900,000
Common Excavation		6,153,220
Rock Excavation		3,349,700
Embankment, Dam		823,200
Backfill		1,715,700
Surface Concrete - M 200		17,955,000
Surface Concrete - M 300		6,424,500
Consolidation Grout		115,500
Core Grout		96,000
Steel		1,417,278
Mechanical, Electrical, Other		15,014,800
Gates, Cranes, Etc.		3,378,000
Switchyard		1,000,000
Transmission Lines (220 kV)		6,350,000
Direct cost Total		69,692,898
Contingency		18,333,589
Subtotal		88,026,487
Engineering and Administration 10%		8,802,649
Project cost total at March 1993 level	**U.S. $**	**96,829,136**

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6.5 Naryn No. 2 Hydroelectric Station Description

The Naryn No. 2 Project described in the following paragraphs corresponds to the THDI concept developed at the pre-feasibility level. It is a diversion project similar in configuration to Naryn 1. However, the Naryn 1 configuration was revised at the feasibility level, from a 2-unit configuration with a design discharge of 100 m^3/s and an installed capacity of about 40 MW to a 4-unit configuration with design discharge of 157 m^3/s and an installed capacity of 62 MW. A similar capacity upgrade was assumed by the THDI engineers for Naryn 2 and 3 as shown on Table 6-1. However, the conceptual design of the Naryn 2 project has not been not upgraded yet. Therefore, the data presented in the following paragraphs still reflect the pre-feasibility level concept with an installed capacity of 38 MW, instead of the 60 MW as shown in Table 6-1. At the next study phase, the design configurations of the Naryn 2 and 3 projects will have to be revised and finalized to take full advantage of the upstream installations.

The layout proposed by the THDI specialists consists of a combined fill and a gated spillway, a power intake leading into a power diversion canal, a forebay as a penstock intake, two steel penstocks, an indoor, surface, 2-unit powerhouse with tailrace canal, and outdoors switchyard. The installed capacity of the plant amounts to some 38 MW (design head of 43.4 m, 2-unit discharge of 100 m^3/s). The average energy production is about 227.5 GWh/yr.

6.5.1 Dam and Spillway

Naryn No. 2 normal headwater level is at elevation 2188 m. Normal tailwater is at 2141 m, which is also the normal headwater level for Naryn No. 3 powerplant. The dam is a 16 m-high, 85,000 m^3 random material fill (sand and pebble), with 1:2.4 (us.) and 1:2.5 (ds.) slopes. The impervious central core is built from a compacted clay and sand mixture with maximum size of 200 mm, grouted over all the height and 10 m into the alluvial foundation.

River floods during plant operation are controlled by a right bank surface spillway provided with four 12.0 x 8.0 m openings controlled by motor-operated radial emergency gates. Upstream of these gates, a set of slots is provided for repairs/maintenance bulkheads operated by crane. The sill is at elevation 2180.0 m, some 6 m above the river bed. The gated weir is embedded into the right valley abutment and has a total width of 66.0 m. The gated spillway discharges into a reinforced concrete canal 340 m-long, and 150 m-wide in average which leads to the river. Spillway capacity with gates fully raised corresponds to the 10000-yr flood peak of 1705 m^3/s which passes almost flush through the openings and flows at elevation 2187.5 m at the initiation of the spillway canal. Maximum normal operating elevation in the dam/spillway forebay is 2188.0 m, which is also the maximum water surface corresponding to the design flood peak passage as controlled by the gated spillway.

6.5.2 Power Intake, Forebay, and Penstocks

The power intake is a reinforced concrete structure adjacent to the fill dam and erected on the left bank of the river. It consists of two 3.5 x 5.0 m openings controlled by gates operated by hydraulic hoists. Upstream of these gates, slots are provided for maintenance bulkheads.

The intake leads power discharges through a 6.0 km-long, practically horizontal power canal, to the penstock intake (canal inlet invert is at elevation 2183.0 m and outlet invert is at 2182.35 m, dropping only 0.65 m over the total length). About 4000 m of derivation consists of a 5.0 m-high trapezoidal canal excavated in the left bank sedimentary deposits. There are practically no fill portions along this reach. Side slopes are 1:1.5 and the top width of the waterway amounts to 20 m. The canal sides and bottom are lined with 20 cm of concrete, placed over 10 cm of equalizing gravel. The rest of about 2000 m are built as a rectangular reinforced concrete canal with a net cross section of 9.0 x 4.9 m. The structure is backfilled against the trench excavated to accommodate it. One cross drainage structure (total length of 50 m), with reinforced concrete open culvert configuration is built at a tributary crossings.

The power conveyance discharges into a 20 m-wide, 40 m-long, 10 m-deep reinforced concrete penstock forebay that includes an intake structure with two openings at the downstream end. The intake is controlled by repair-maintenance slide gates operated by hydraulic hoists. Upstream the gates location, trash racks and slots for maintenance bulkheads are provided. Two prefabricated concrete pipes convey water over a 160 m mild slope terrain. Two exposed steel penstocks with 3.5 m I.D., convey the water over a 32 m vertical drop to the powerhouse. The penstocks are supported by a reinforced concrete sloped slab, down to the powerhouse. Penstocks are about 50 m-long and are anchored into the slab by ring girders every 10 m.

6.5.3 Powerhouse

The indoor, surface power house is a 41.5 m-long (including erection bay), 26 m-wide (including draft tube deck), structure located on the left bank of Naryn. Pit excavation is some 16 m into the defluvium, to elevation 2133.6 m. It has two 20 MW, RO 75/728b-V-250 normalized units. Design discharge is 50 m^3/s per unit. Runner diameter is 2.5 m. The two generators type SV 617/101-28 UHL4 are rated at 19 MW, 0.8 cos fi, 6.3 kV.

Two transformers TD 25000/220/11 are installed on the powerhouse upstream deck at elevation 2150.0 (same as the generator floor).

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The draft tubes are controlled by gates operated by a crane installed at elevation 2150.0 m. Discharge is returned to the river through a 50 m-long tailrace canal. Plant design flood peak (1705 m^3/s) elevation at the discharge point is 2147.0 m.

6.5.4 Switchyard

The 180 x 100 m outdoors 220 kV switchyard is located also on the left bank of the river, at elevation 2160.0 m. The construction is part excavation, part fill. The platform is connected to the transformer deck by 350 m-long aerial cables.

6.5.5 Transmission Interconnection

The project would be interconnected to a new 220-kV transmission line which would be routed along the Naryn river.

6.5.6 Access Road

A two-lane, hard cover road transitable by heavy trucks and other construction equipment, as well as by city vehicles, is in operation presently, being used for transit to the city of Naryn and to other communities in the area. No portions of this road will have to be relocated to accommodate the construction of the Naryn Nr.2 power station.

6.5.7 Construction Cost Estimate

No detailed cost estimate was performed for this project. However, a comparison was made for the Dzhanykel and Naryn 1 projects between of the THDI original costs and the revised costs as presented in Tables 6-1 and 6-2. Based on that comparison, it is expected that the cost of the Naryn No. 2 project would be in the order of $95 to 105 million.

6.6 Naryn No. 3 Hydroelectric Station Description

The Naryn No. 3 Project described in the following paragraphs corresponds to the THDI concept developed at the pre-feasibility level. It is a diversion project similar in configuration to Naryn 1. However, the Naryn 1 configuration was revised at the feasibility level, from a 2-unit configuration with a design discharge of 100 m^3/s and an installed capacity of about 40 MW to a 4-unit configuration with design discharge of 157 m^3/s and an installed capacity of 62 MW. A similar capacity upgrade was assumed by the THDI engineers for Naryn 3 as shown on Table 6-1. However, the conceptual design of the Naryn 3 project has

not been not upgraded yet. Therefore, the data presented in the following paragraphs still reflect the pre-feasibility level concept with an installed capacity of 48 MW, instead of the 60 MW as shown in Table 6-1. At the next study phase, the design configurations of the Naryn 3 project will have to be revised and finalized to take full advantage of the upstream installations.

The layout proposed by the THDI specialists consists of a combined fill and a surface gated spillway, a power intake leading into a power diversion canal, a forebay as a penstock intake, two steel penstocks, an indoor, surface, 2-unit powerhouse with tailrace canal, and outdoors switchyard. Design head is 50 m. The installed capacity of the plant amounts to some 47 MW (2-unit discharge of 105 m^3/s). The average energy production is 260 GWh/yr.

6.6.1 Dam and Spillway

Naryn No. 3 normal headwater level is at elevation 2141 m. Normal tailwater is at 2085.6 m. The dam is a 14 m-high, 100,000 m^3 random material fill (sand and pebble), with 1:3 (us.) and 1:2.2 (ds.) slopes. The impervious central core is built from a compacted clay and sand mixture with maximum size of 200 mm, grouted over all the height and 15 m into the alluvial foundation.

River floods during plant operation are controlled by a right bank surface spillway provided with seven 10.0 x 6.0 m openings controlled by motor-operated radial emergency gates. Upstream of these gates, a set of slots is provided for repairs/maintenance bulkheads operated by crane. The sill is at elevation 2135.0 m, some 5 m above the river bed. The gated weir is embedded into the right valley abutment and has a total width of 93.0 m. The gated spillway discharges into a reinforced concrete canal 630 m-long, and 70 m-wide in average which leads to the river. Spillway capacity with gates fully raised corresponds to the 10000-yr flood peak of 1705 m^3/s which passes almost flush through the openings and flows at elevation 2140.0 m at the initiation of the spillway canal. Maximum normal operating elevation in the dam/spillway forebay is 2141.0 m, which is also the maximum water surface corresponding to the design flood peak passage as controlled by the gated spillway.

6.6.2 Power Intake, Forebay, and Penstocks

The power intake is a reinforced concrete structure adjacent to the fill dam and erected on the left bank of the river. It consists of two 3.5 x 5.0 m openings controlled by gates operated by hydraulic hoists. Upstream of these gates, slots are provided for maintenance bulkheads.

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The intake leads power discharges through a 8.3 km-long, practically horizontal power canal, to the penstock intake (canal inlet invert is at elevation 2136.0 m and outlet invert is at 2134.75 m, dropping only 1.25 m over the total length). About 5600 m of derivation consists of a 5.0 m-high trapezoidal canal excavated in the left bank sedimentary deposits. There are practically no fill portions along this reach. Side slopes are 1:1.5 and the top width of the waterway amounts to 20 m. The canal sides and bottom are lined with 20 cm of concrete, placed over 10 cm of equalizing gravel. About 2000 m are built as a rectangular reinforced concrete canal with a net cross section of 9.0 x 4.9 m. The structure is backfilled against the trench excavated to accommodate it. One cross drainage structure (total length of 350 m), with reinforced concrete open culvert configuration is built at a tributary crossing. One 720 m reach is built as low pressure tunnel.

The power conveyance discharges into a 20 m-wide, 39 m-long, 13 m-deep reinforced concrete penstock forebay that includes an intake structure with two openings at the downstream end. The intake is controlled by repair-maintenance slide gates operated by hydraulic hoists. Upstream the gates location, trash racks and slots for maintenance bulkheads are provided. Two prefabricated concrete pipes with 3.8 m I.D., convey the water over a 900 m mild slope. Two exposed steel penstocks supported by a reinforced concrete slab convey water to the powerhouse at elevation 2085.6 (unit centerline). Penstocks are about 60 m-long and are anchored into the slab by ring girders every 10 m.

6.6.3 Powerhouse

The indoor, surface powerhouse is a 40.5 m-long (including erection bay), 24.5 m-wide (including draft tube deck), structure located on the left bank of Naryn. Pit excavation is some 16 m into the defluvium, to elevation 2078.0 m. It has two 24 MW, RO 75/728b-V-250 normalized units. Design discharge is 50 m^3/s per unit. Runner diameter is 2.5 m. The two generators type SV 617/104-28 UHL4 are rated at 23.5 MW, 0.8 cos fi, 6.3 kV.

Two transformers TD 25000/220/11 are installed on the powerhouse upstream deck at elevation 2094.4 (same as the generator floor).

The draft tubes are controlled by gates operated by a crane installed at elevation 2094.4 m. Discharge is returned to the river through a 50 m-long tailrace canal. Plant design flood peak (1705 m^3/s) elevation at the discharge point is 2085.6 m.

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6.6.4 Switchyard

The 180 m x 100 m outdoors 220 kV switchyard is located also on the left bank of the river, at elevation 2110.0 m. The construction is part excavation, part fill. The platform is connected to the transformer deck by 150 m-long aerial cables.

6.6.5 Transmission Interconnection

The project would be interconnected to a new 220-kV transmission line which would be routed along the Naryn river.

6.6.6 Access Road

A two-lane, hard cover road transitable by heavy trucks and other construction equipment, as well as by city vehicles, is in operation presently, being used for transit to the city of Naryn and to other communities in the area. No portions of this road will have to be relocated to accommodate the construction of the Naryn Nr.3 power station.

6.6.7 Construction Cost

No detailed cost estimate was performed for this project. However, a comparison was made for the Dzhanikel and Naryn 1 projects between of the THDI original costs and the revised costs as presented in Tables 6-1 and 6-2. Based on that comparison, it is expected that the cost of the Naryn No. 3 project would be in the order of $110 to 120 million.

6.7 Akbulun Hydroelectric Station Description

The layout proposed by the THDI specialists at the pre feasibility level consists of a 73 m-high random fill (sand and pebble), rock protected dam with a total material volume of 1,670,000 m^3, two (tunnel low-level and canal surface) spillways with a total capacity of 1450 m^3/s (representing a slight reservoir attenuation of the 10000-yr design flood peak of 1554 m^3/s), a left bank power intake leading into a 2.5 km power diversion canal, a forebay as a penstock intake, two 3.6 m I.D. concrete penstocks, an indoor, surface, 2-unit powerhouse with short tailrace canal, and outdoors switchyard. The normalized turbines are of the type RO 75/728b-V-220. Normal maximum operation level in the dam forebay is at elevation 2315.0 m and normal tailwater is at elevation 2235 m. Design head is 74.0 m. and design discharge amounts to 78.5 m^3/s per unit. Two SV-617/96-28 generators and two TD-40000/220/11 transformers are included in the configuration. The installed capacity of the

plant amounts to 100 MW and the average energy production is 372 GWh/yr. The construction cost is expected to be in the order of $130 to 140 million.

6.8 Oruktam No. 1 Hydroelectric Station Description

This project represents the only significant storage proposed on the Small Naryn river. The layout proposed by the THDI specialists at the pre feasibility level includes a 137 m-high random fill (sand and pebble) dam, rock riprap-protected on the faces and with a central asphaltic membrane projected into the alluvium foundation and surrounded by filter material. A 65 m-deep grout curtain is provided below the membrane. The total dam material volume amounts to 5,315,000 m^3 and the live volume of the reservoir amounts to 431 million m^3 (normal maximum operation level in the dam forebay is at elevation 2600.0 m). A common intake structure with unequal openings diverts water to feed both the power and the spillway tunnels, depending on the magnitude of the river flow. Tunnels run parallel on the left bank of Naryn over most of the alignment and are horseshoe shaped, lined with reinforced concrete and grouted beyond the liner. The 285 m-long spillway tunnel with a 7.5 m I.D. discharges flood peaks into the Naryn through an energy dissipation structure, 50 m downstream of the powerhouse location. The 280 m-long power tunnel with a 4.5 m I.D. includes a 63 m-deep vertical shaft and a 88 m-long horizontal reach to the steel wye distributor. Steel penstock branches are about 50 m-long. Both wye and branches have 3.5 m I.D. The distributor feeds an indoor, surface, 2-unit powerhouse with short tailrace canal, and outdoors switchyard. The normalized turbines are of the type RO 140/810b-V-190. Normal tailwater is at elevation 2480.0 m. Design head is 97 m. and design discharge amounts to 35 m^3/s per unit. Two SV-404/129-16 generators and two transformers are included in the configuration. The installed capacity of the plant amounts to 60 MW and the average energy production is 254.3 GWh/yr. The construction cost is expected to be in the order of $175 to 185 million.

6.9 Oruktam No. 2 Hydroelectric Station Description

This is a diversion development on Small Naryn river intended to generate based on the operation mode of the upstream development at Oruktam 1. The 9.46 km-long power tunnel intakes immediately downstream of the Oruktam 1 tailrace, where normal tailwater is at elevation 2480.0 m and coincides with the Oruktam 2 normal headwater elevation. The tunnel is followed by a 130 m-deep vertical shaft to reach the underground the steel wye distributor. The distributor feeds an indoor, surface, 2-unit powerhouse with short tailrace canal, and outdoors switchyard. Two normalized turbines and two standard generators are installed in the powerhouse. Normal tailwater is at elevation 2340.0 m. Design head is 112.4 m. and design discharge amounts to 25 m^3/s per unit. The installed capacity of the plant is

48 MW and the average energy production is 259 GWh/yr. The construction cost is expected to be in the order of $175 to 185 million.

6.10 Echinaryn Hydroelectric Station Description

This is the second diversion development on Small Naryn river intended to generate based on the operation mode of the upstream development at Oruktam 1. The plant is a low-head installation. The 2.91 km-long power canal intakes immediately downstream of the Oruktam 2 tailrace, where normal tailwater is at elevation 2340.0 m and coincides with the Echinaryn normal headwater elevation. The canal enters a small forebay structure which includes a penstock intake. The penstock feeds through a distributor an indoor, surface, 2-unit powerhouse with short tailrace canal, and outdoors switchyard. Two normalized turbines and two standard generators are installed in the powerhouse. Normal tailwater is at elevation 2315.0 m. Design head is 21.55 m. and design discharge amounts to 25 m^3/s per unit. The installed capacity of the plant is 9.5 MW and the average energy production is 49.7 GWh/yr. The construction cost is expected to be in the order of $35 to 40 million.

EXHIBIT 6-1

DJANIKEL PROJECT All Costs in US Dollars

COST ESTIMATE FOR DJANIKEL PROJECT

ITEM DESCRIPTION	TOTAL COST
General	5,900,000
Common Excavation	310,300
Rock Excavation	1,069,280
Underground Excav.- Tunnels	10,192,000
Underground Excav.- Vertical Tunnels	860,000
Dam embankment	16,329,600
Backfill	98,280
Surface Concrete - M 200 Concrete	9,544,500
Surface Concrete - M 300 Concrete	12,078,000
Underground Concrete	7,282,000
Consolidation Grout	5,557,500
Core Grouting (in Dam)	600,000
Shotcrete	750,000
Steel	6,926,590
Mechanical, Electrical, and Other	25,553,750
Gates, Cranes, Etc.	15,591,000
Switchyard	1,000,000
Transmission Line (220 kV)	7,620,000
Total	127,262,800
Contingency	33,202,365
Total w/ Contingency	160,465,165
Engineering & Administration	16,046,517
Project cost at March 1993 level	176,511,682
All Costs in US Dollars	

DJANIKEL PROJECT

All Costs In US Dollars

COST ESTIMATE FOR DJANIKEL PROJECT

KYRGYZSTAN LABOR RATES, INTERNATIONAL MATERIAL PRICES AND MODIFIED EQUIPMENT RATES, AT MARCH 1993 LEVEL

RANDOM FILL DAM ESTIMATE

Item #	Description		Quantity	Unit	Rate	Total
1	General					
1.1	Mobilization and Demobilization		1	LS	5,000,000	5,000,000
1.2	Access Roads		1	LS	500,000	500,000
1.3	Housing and Camp		1	LS	400,000	400,000
	Total Cost Item 1					5,900,000
2	Total Excavations & Backfills					
2.1	Common Excavation	Cu M				
2.11	Power Intake	42,000				
2.12	Dam	34,000				
2.13	Access Tunnel	6,000				
2.14	Powerhouse	25,000				
	Total Qty	107,000				
	Total Cost Item 2.1		107,000	Cu M	2.90	310,300
2.2	Rock Excavation	Cu M				
2.21	Power Intake	84,000				
2.22	Access Tunnel	1,500				
2.23	Dam	47,000				
2.24	Powerhouse	31,000				
2.25	Spillway Tunnel	48,000				
2.26	Switchyard	49,300				
	Total Qty	260,800				
	Total Cost Item 2.2		260,800	Cu M	4.10	1,069,280

DJANIKEL PROJECT

All Costs In US Dollars

COST ESTIMATE FOR DJANIKEL PROJECT

KYRGYZSTAN LABOR RATES, INTERNATIONAL MATERIAL PRICES AND MODIFIED EQUIPMENT RATES, AT MARCH 1993 LEVEL

RANDOM FILL DAM ESTIMATE

Item #	Description		Quantity	Unit	Rate	Total
2.3	Underground Excav. - Tunnels	Cu M				
2.31	Spillway Tunnel	47,500				
2.32	Dam	105,000				
2.33	Access Tunnel	12,000				
2.34	Power Tunnels	17,500				
	Total Qty	182,000				
	Total Cost Item 2.3		182,000	Cu M	56	10,192,000
2.4	Underground Excav. - Vertical Tunnels	Cu M				
2.41	Vertical Tunneling	10,000				
	Total Qty	10,000	10,000	Cu M	86	860,000
	Total Cost Item 2.4					
2.5	Embankment, Dam	Cu M				
2.51	Sand/Clay	3,375,000				
2.52	Gravel	395,000				
2.53	Rockfill	1,090,000				
	Total Qty	4,860,000				
	Total Cost Item 2.5		4,860,000	Cu M	3.36	16,329,600
2.6	Backfill		46,800	Cu M	2.10	98,280

DJANIKEL PROJECT

All Costs In US Dollars

COST ESTIMATE FOR DJANIKEL PROJECT

KYRGYZSTAN LABOR RATES, INTERNATIONAL MATERIAL PRICES AND MODIFIED EQUIPMENT RATES, AT MARCH 1993 LEVEL

RANDOM FILL DAM ESTIMATE

Item #	Description		Quantity	Unit	Rate	Total
3	Surface Concrete					
3.1	M 200 Concrete	Cu M				
3.11	Dam	22,000				
3.12	Powerhouse	8,000				
3.13	Diaphragm	35,000				
3.14	Switchyard	3,200				
3.15	Miscellaneous	2,500				
	Total Qty	70,700				
	Total Cost Item 3.1		70,700	Cu M	135	9,544,500
3.2	M 300 Concrete	Cu M				
3.21	Dam	2,000				
3.22	Powerhouse	9,720				
3.23	Switchyard	600				
3.24	Power Intake	52,000				
3.25	Miscellaneous	7,700				
3.26	Spillway Tunnel	8,500				
	Total Qty	80,520				
	Total Cost Item 3.2		80,520	Cu M	150	12,078,000
4	Underground Concrete	Cu M				
4.1	Dam	13,000				
4.2	Power Tunnel	9,600				
4.3	Spillway Tunnel	10,500				
	Total Qty	33,100				
	Total Cost Item 4		33,100	Cu M	220	7,282,000

COST ESTIMATE FOR DJANIKEL PROJECT

KYRGYZSTAN LABOR RATES, INTERNATIONAL MATERIAL PRICES AND MODIFIED EQUIPMENT RATES, AT MARCH 1993 LEVEL

RANDOM FILL DAM ESTIMATE

Item #	Description		Quantity	Unit	Rate	Total
5	Grout					
5.1	Consolidation Grout	Cu M				
5.11	Spillway Tunnel	51,000				
5.12	Power Canal	62,100				
5.13	Dam	12,000				
	Total Qty	74,100				
	Total Cost Item 5.1		74,100	Cu M	75	5,557,500
5.2	Core Grouting (In Dam)		20,000	Sq M	30	600,000
6	Shotcrete		10,000	Cu M	75	750,000
7	Steel					
7.1	Penstock Steel Liner		3,160	Tonne	2,062	6,515,920
7.2	Structural Steel		195	Tonne	2,106	410,670
	Total Cost Item 7					6,926,590
8	Mechanical, Electrical, and Other					
8.1	Francis Units 65 MW		2	Ea	4,327,000	8,654,000
8.2	Transformers		2	Ea	540,875	1,081,750
8.3	Generators, 65 MW		2	Ea	4,120,000	8,240,000
8.4	Miscellaneous Mech		1	LS	6,960,000	6,960,000
8.5	Miscellaneous Elec		1	LS	618,000	618,000
	Total Cost Item 8					25,553,750

DJANIKEL PROJECT

All Costs In US Dollars

COST ESTIMATE FOR DJANIKEL PROJECT

KYRGYZSTAN LABOR RATES, INTERNATIONAL MATERIAL PRICES AND MODIFIED EQUIPMENT RATES, AT MARCH 1993 LEVEL

RANDOM FILL DAM ESTIMATE

Item #	Description	Quantity	Unit	Rate	Total
9	Gates, Cranes, Etc.				
9.1	Gates, Hoists, Etc.	1	LS	12,836,000	12,836,000
9.2	Cranes	1	LS	2,755,000	2,755,000
	Total Cost Item 9				15,591,000
10	Switchyard	1	LS	1,000,000	1,000,000
11	Transmission Line (220 kV)	30	Km	254,000	7,620,000
					127,262,800
	Contingency, Civil work	30%			23,249,415
	Contingency, All Other Work	20%			9,952,950
					160,465,165
	Engineering and Administration	10%			16,046,517
	Total cost @ March 1993 Level				176,511,682

COST ESTIMATE FOR UPPER NARYN #1

ITEM DESCRIPTION	TOTAL COST
General	5,900,000
Common Excavation	6,153,220
Rock Excavation	3,349,700
Embankment, Dam	823,200
Backfill	1,715,700
Surface Concrete - M 200 Concrete	17,955,000
Surface Concrete - M 300 Concrete	6,424,500
Consolidation Grout	115,500
Core Grout	96,000
Steel	1,417,278
Mechanical, Electrical, and Other	15,014,800
Gates and Cranes	3,378,000
Switchyard	1,000,000
Transmission Line (220 kV)	6,350,000
Total	69,692,898
Contingency	18,333,589
Total with Contingency	88,026,487
Engineering & Administration	8,802,649
Project Cost at March 1993 Level	96,829,136
All Costs in US Dollars	

UPPER NARYN FILL DAM

All Costs In US Dollars

COST ESTIMATE FOR UPPER NARYN #1

KYRGYZSTAN LABOR RATES, INTERNATIONAL MATERIAL PRICES AND MODIFIED EQUIPMENT RATES, AT MARCH 1993 LEVEL

RANDOM FILL DAM ESTIMATE

Item #	Description		Quantity	Unit	Rate	Total
1	General					
1.1	Mobilization and Demobilization		1	LS	5,000,000	5,000,000
1.2	Access Roads		1	LS	500,000	500,000
1.3	Housing and Camp		1	LS	400,000	400,000
	Total Cost Item 1					5,900,000
2	Total Excavations					
2.1	Common Excavation	Cu M				
2.11	Power & Div. Canal	1,314,000				
2.12	Headpond & Penstock	110,000				
2.13	Dam	15,200				
2.14	Tailrace	325,000				
2.15	Powerhouse	320,000				
2.16	Spillway	30,000				
2.17	Switchyard & Others	7,600				
	Total Qty	2,121,800				
	Total Cost Item 2.1		2,121,800	Cu M	2.90	6,153,220
2.2	Rock Excavation	Cu M				
2.21	Power & Div. Canal	702,000				
2.22	Headpond & penstock	11,000				
2.23	Dam	4,000				
2.24	Powerhouse	53,000				
2.25	Spillway	47,000				
	Total Qty	817,000				
	Total Cost Item 2.2		817,000	Cu M	4.10	3,349,700

UPPER NARYN FILL DAM

All Costs In US Dollars

COST ESTIMATE FOR UPPER NARYN #1

KYRGYZSTAN LABOR RATES, INTERNATIONAL MATERIAL PRICES AND MODIFIED EQUIPMENT RATES, AT MARCH 1993 LEVEL

RANDOM FILL DAM ESTIMATE

Item #	Description		Quantity	Unit	Rate	Total
3	Fills					
3.1	Embankment, Dam	Cu M				
3.11	Rock	77,500				
3.12	Random	167,500				
	Total Qty	245,000				
	Total Cost Item 3.1		245,000	Cu M	3.36	823,200
3.2	Backfill		817,000	Cu M	2.10	1,715,700
4	Surface Concrete					
4.1	M 200 Concrete	Cu M				
4.11	Spillway	10,000				
4.12	Dam	22,300				
4.13	Power canal	52,400				
4.14	Powerhouse	17,600				
4.15	Headpond	22,500				
4.16	Switchyard	3,200				
4.17	Miscellaneous	5,000				
	Total Qty	133,000				
	Total Cost Item 4.1		133,000	Cu M	135	17,955,000
4.2	M 300 Concrete	Cu M				
4.21	Dam	550				
4.22	Powerhouse	17,600				
4.23	Headpond	280				
4.24	Switchyard	600				
4.25	Power Intake	6,900				
4.26	Miscellaneous	7,700				
	Spillway	9,200				
	Total Qty	42,830				
	Total Cost Item 4.2		42,830	Cu M	150	6,424,500

UPPER NARYN FILL DAM

All Costs in US Dollars

COST ESTIMATE FOR UPPER NARYN #1

KYRGYZSTAN LABOR RATES, INTERNATIONAL MATERIAL PRICES AND MODIFIED EQUIPMENT RATES, AT MARCH 1993 LEVEL

RANDOM FILL DAM ESTIMATE

Item #	Description		Quantity	Unit	Rate	Total
5	Grout					
5.1	Consolidation Grout	Sq M				
5.11	Power Canal	500				
5.12	Dam	3,350				
	Total Qty	3,850				
	Total Cost Item 5.1		3,850	Sq M	30	115,500
5.2	Core Grout					
5.21	Dam		3,200	Sq M	30	96,000
6	Steel					
6.1	Penstock Steel Liner		480	Tonne	2,062	989,760
6.2	Structural steel		203	Tonne	2,106	427,518
	Total Cost Item 6					1,417,278

UPPER NARYN FILL DAM

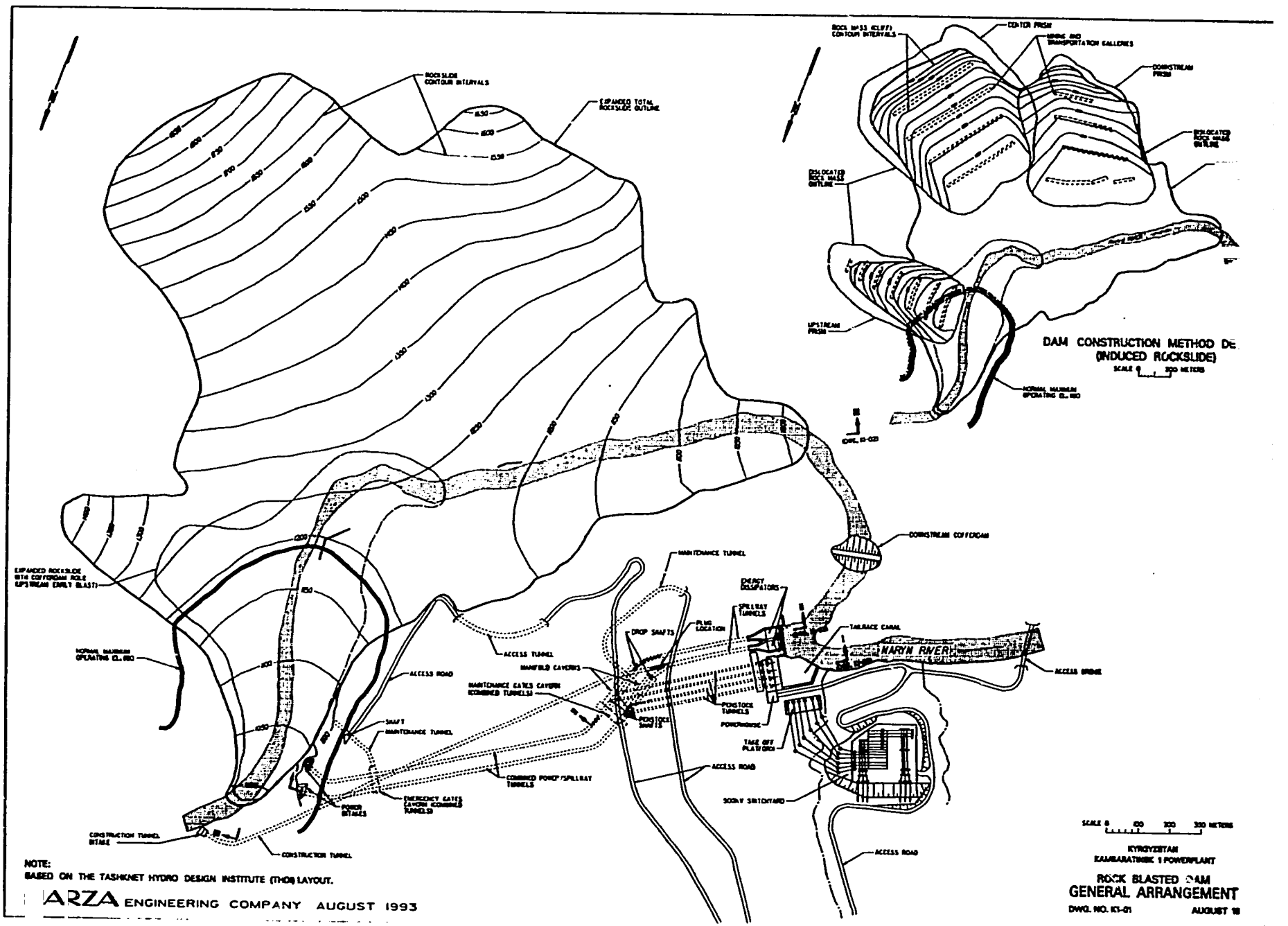
All Costs in US Dollars

COST ESTIMATE FOR UPPER NARYN #1

KYRGYZSTAN LABOR RATES, INTERNATIONAL MATERIAL PRICES AND MODIFIED EQUIPMENT RATES, AT MARCH 1993 LEVEL

RANDOM FILL DAM ESTIMATE

Item #	Description	Quantity	Unit	Rate	Total
7	Mechanical, Electrical, and Other				
7.1	Francis Units 24.9 Mw	2	Ea	2,183,000	4,366,000
7.2	Generators. 8.75 MVA	2	Ea	1,992,000	3,984,000
7.3	Francis Units 7.25 Mw	2	Ea	609,000	1,218,000
7.4	Transformers	2	Ea	349,000	698,000
7.5	Generators 30 MVA	2	Ea	1,800,000	3,600,000
7.6	Miscellaneous Mech.	1	LS	580,000	580,000
7.7	Miscellaneous Elec.	1	LS	568,800	568,800
	Total Cost Item 7				15,014,800
8	Gates and Cranes				
8.1	Gates	626	Sq M	3,000	1,878,000
8.2	Cranes	1	LS	1,500,000	1,500,000
	Total Cost Item 8				3,378,000
9	Switchyard	1	LS	1,000,000	1,000,000
10	Transmission Line (220 kV)	25	Km	254,000	6,350,000
					69,692,898
	Contingency, Civil work	30%			13,185,029
	Contingency, All other work	20%			5,148,560
					88,026,487
	Engineering and Administration	10%			8,802,649
	Total Cost @ March 1993 Level				96,829,136



NOTE:
BASED ON THE TASHKNET HYDRO DESIGN INSTITUTE (THDI) LAYOUT.

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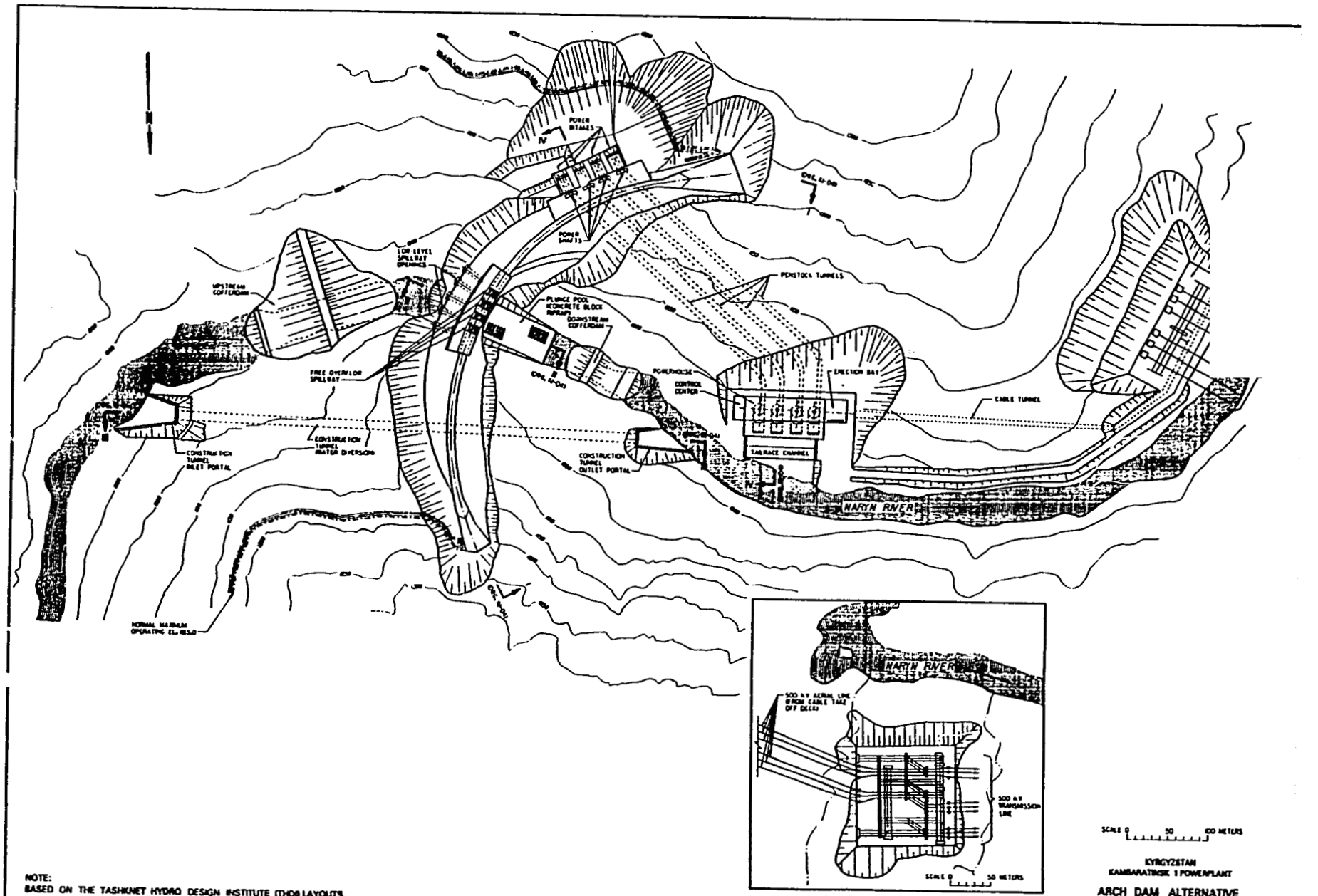

INSET MAP – 500 kV SWITCHYARD

NOTE:
BASED ON THE TASHKNET HYDRO DESIGN INSTITUTE (THDI) LAYOUTS.

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KYRGYZSTAN
KAMBARATINSK I POWERPLANT

ARCH DAM ALTERNATIVE
GENERAL ARRANGEMENT

DWG. NO. K1-03 AUGUST

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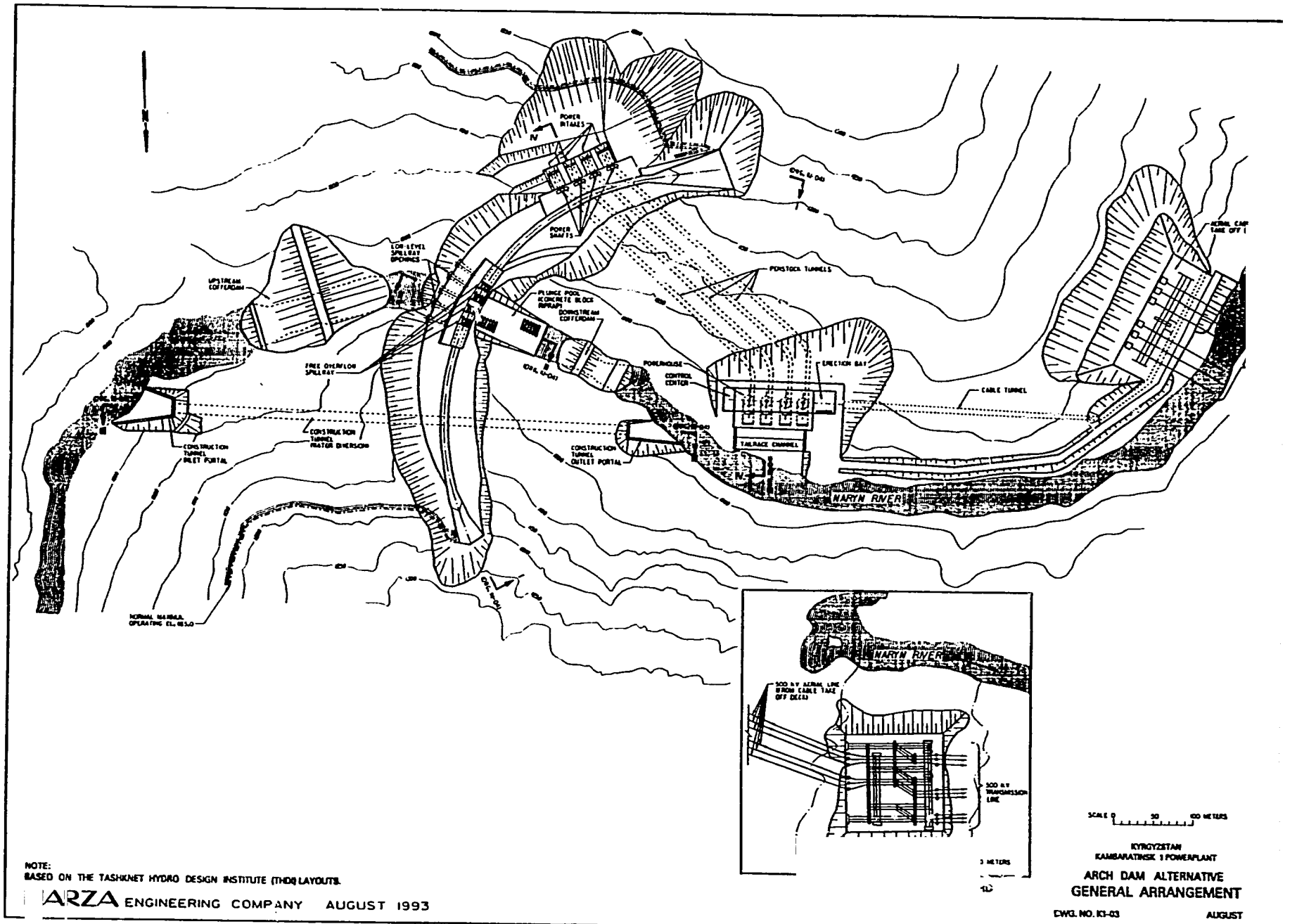

NOTE:
BASED ON THE TASHKNET HYDRO DESIGN INSTITUTE (THDI) LAYOUTS.

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KYRGYZSTAN
KAMBARATINSK 1 POWERPLANT

ARCH DAM ALTERNATIVE
GENERAL ARRANGEMENT

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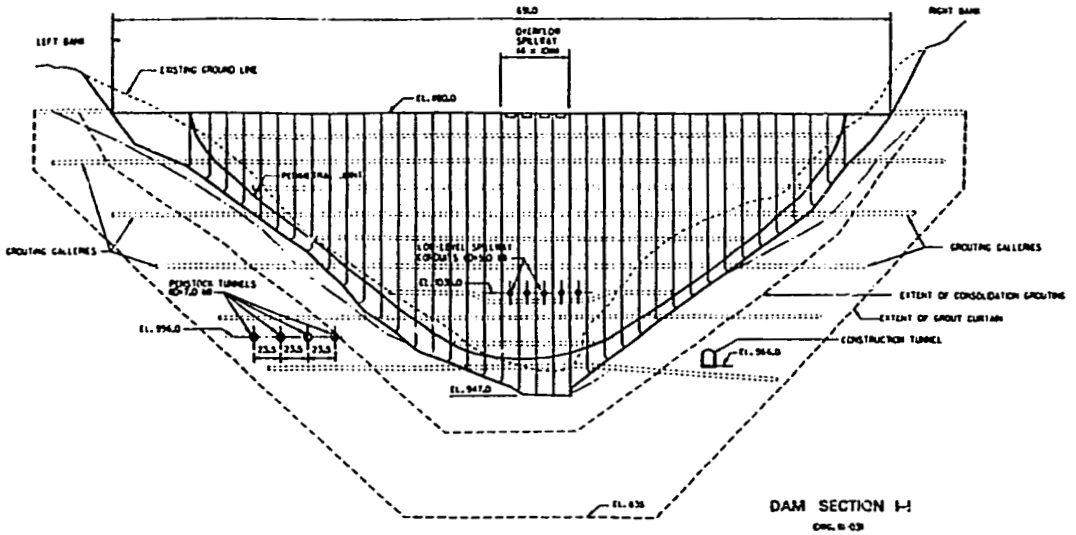
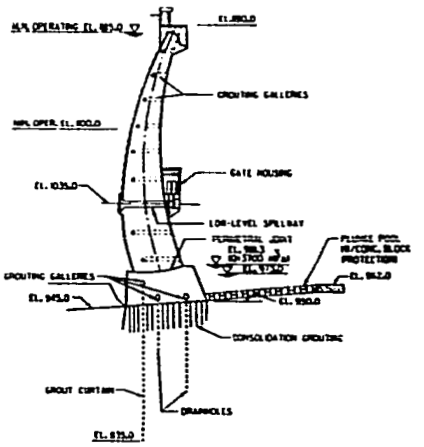


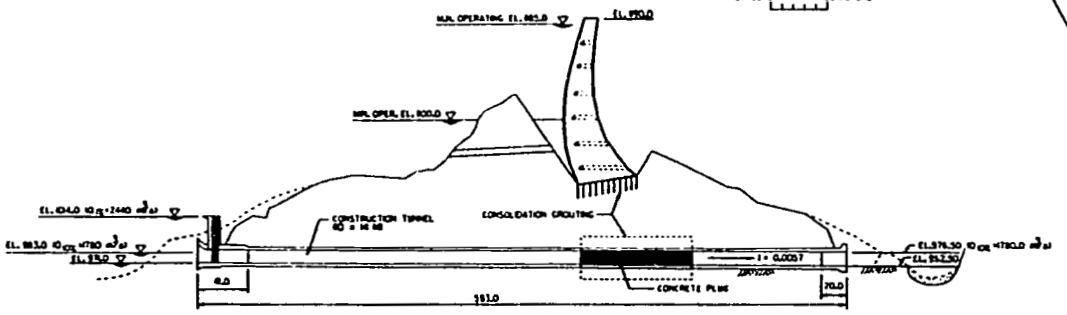
DAM SECTION I-I

SCALE 0 50 METERS



DAM SECTION II-II

SCALE 0 50 METERS



CONSTRUCTION TUNNEL SECTION III-III

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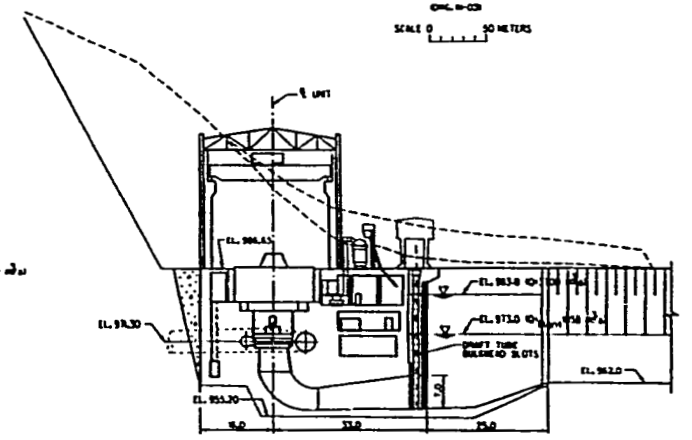
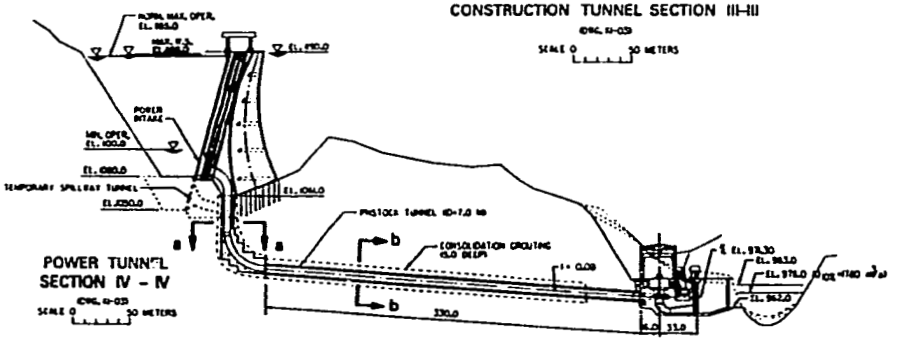


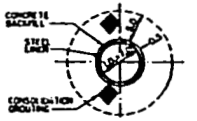
POWERHOUSE TRANSVERSE SECTION

SCALE 0 10 METERS



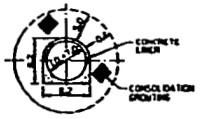
POWER TUNNEL SECTION IV - IV

SCALE 0 50 METERS



SECTION a - a (SHAFT)

SCALE 0 10 METERS



SECTION b - b (TUNNEL)

SCALE 0 10 METERS

NOTE:
BASED ON THE TASHKENT HYDRO DESIGN INSTITUTE (THDI) LAYOUTS.

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KYRGYZSTAN
KAMBARATINSK 1 POWERPLANT

ARCH DAM ALTERNATIVE SECTIONS

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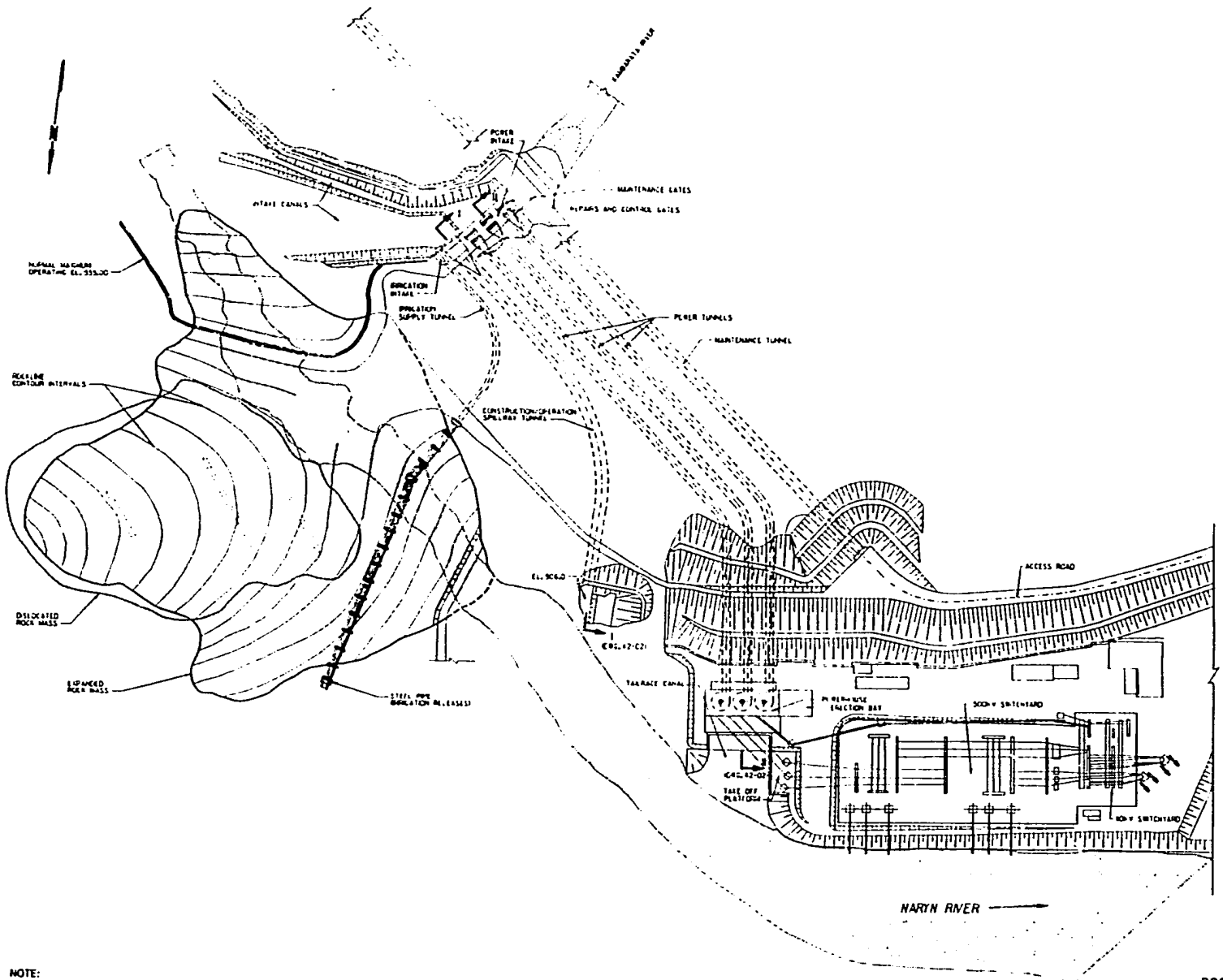

NOTE:
BASED ON THE TASHKENT HYDRO DESIGN INSTITUTE (THDI) LAYOUTS

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KYRGYZSTAN
KAMBARATINSK 2 POWERPLANT

ROCK BLASTED DAM ALTERNATIVE
GENERAL ARRANGEMENT

DWG NO. K2-01 AUGUST 1993

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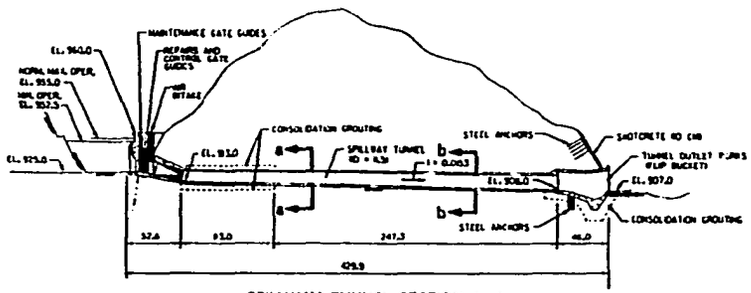

SPILLWAY TUNNEL SECTION I - I

(DWG. K2-01)

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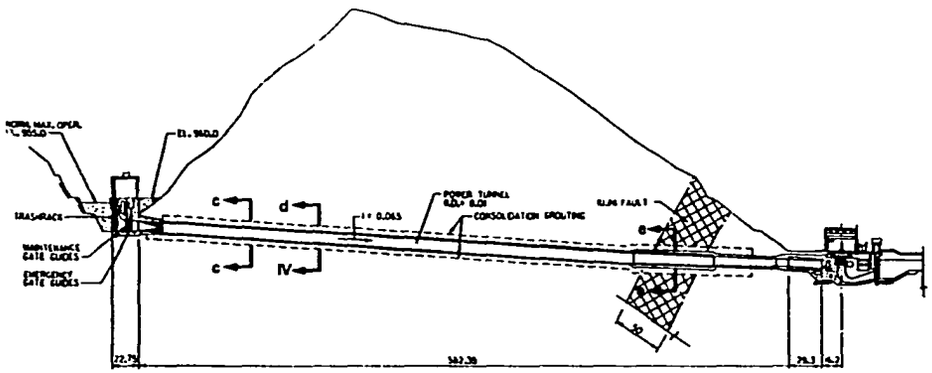

POWER TUNNEL SECTION II - II

(DWG. K2-03)

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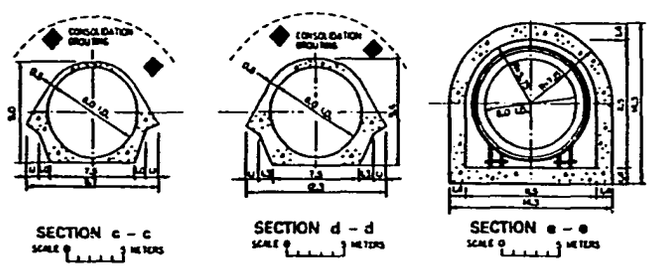


SECTION c - c

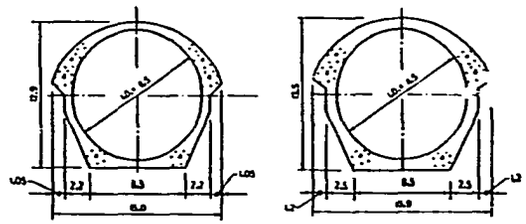
SCALE 0 3 METERS

SECTION d - d

SCALE 0 3 METERS

SECTION e - e

SCALE 0 3 METERS

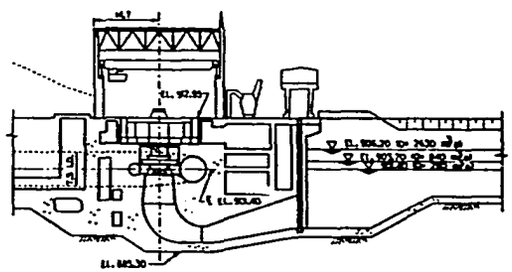


SECTION a - a

SCALE 0 3 METERS

SECTION b - b

SCALE 0 3 METERS



POWERHOUSE TRANSVERSE SECTION

SCALE 0 10 METERS

NOTE:
BASED ON THE TASHKENT HYDRO DESIGN INSTITUTE (THDI) LAYOUTS.

ARZA ENGINEERING COMPANY AUGUST 1993

KYRGYZSTAN
KAMBARATINSK 2 POWERPLANT

ROCK BLASTED DAM ALTERNATIVE
SECTIONS

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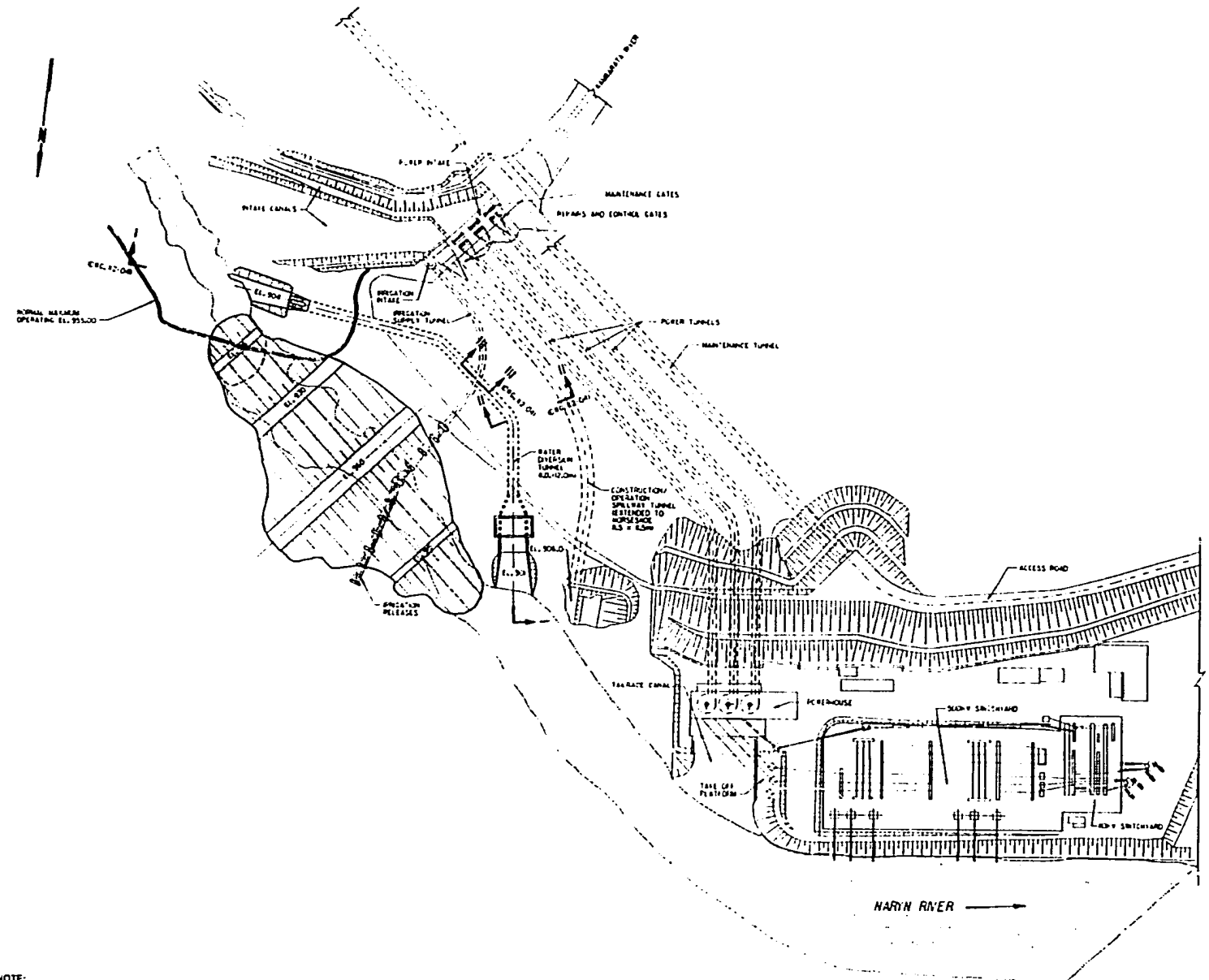

NOTE:
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ARZA ENGINEERING COMPANY AUGUST 1993

SCALE 0 50 100 METERS

KYRGYZSTAN
KAMBARATINSK 2 POWERPLANT

RANDOM FILL DAM ALTERNATIVE
GENERAL ARRANGEMENT

DWG. NO K2-03 AUGUST 1993

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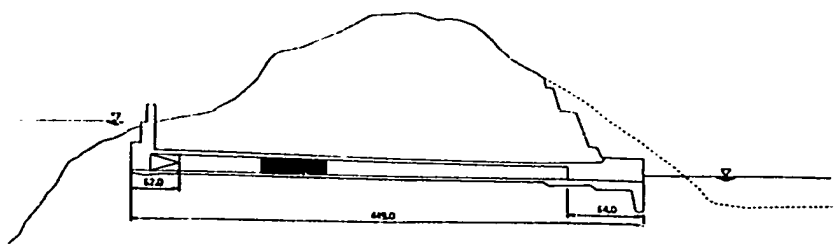

DIVERSION TUNNEL SECTION I – I

(DWG. K2-03)

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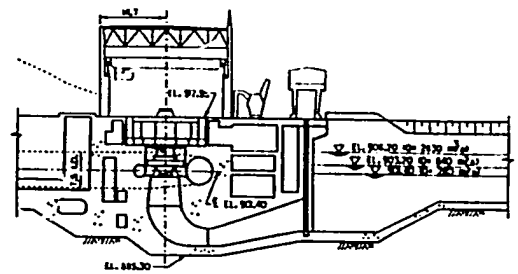
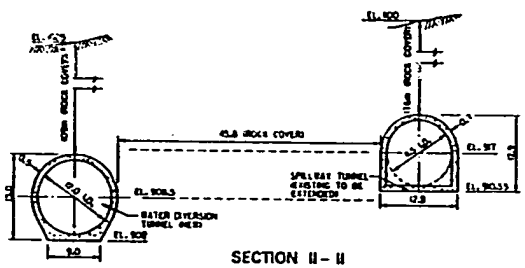


POWERHOUSE TRANSVERSE SECTION

SCALE 0 10 METERS



SECTION II – II

(DWG. K2-03)

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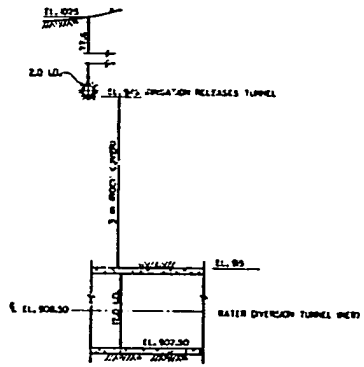

SECTION III – III

(DWG. K2-03)

SCALE 0 10 METERS

NOTE:
BASED ON THE TASHKENT HYDRO DESIGN INSTITUTE (THDI) LAYOUTS.

ARZA ENGINEERING COMPANY AUGUST 1993

KYRGYZSTAN
KAMBARATINSK 2 POWERPLANT

RANDOM FILL DAM ALTERNATIVE
SECTIONS

DWG. NO. K2-04 AUGUST 1993

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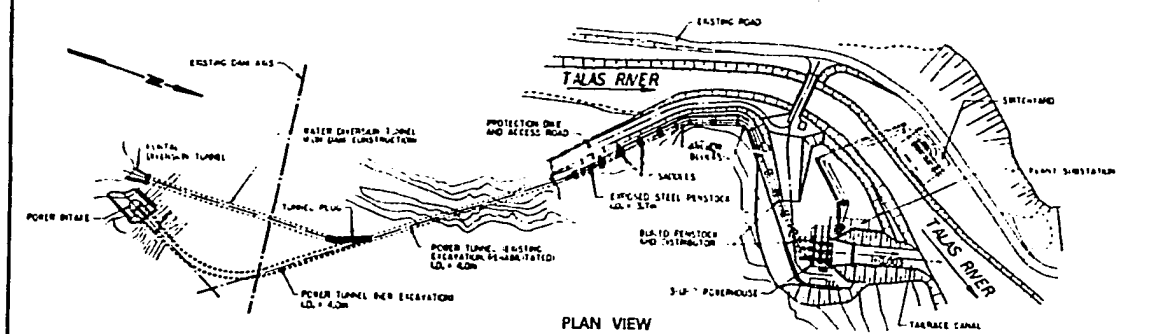
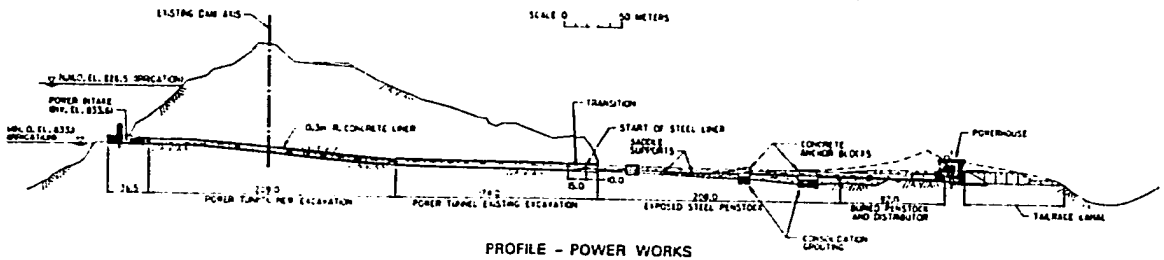


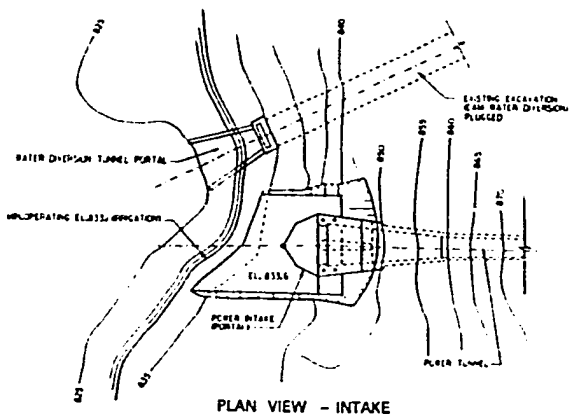
PLAN VIEW

SCALE 0 50 METERS



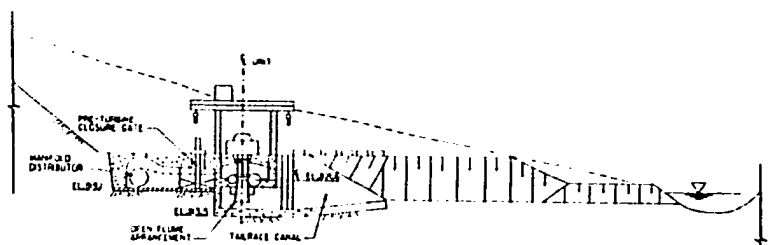
PROFILE - POWER WORKS

SCALE 0 50 METERS



PLAN VIEW - INTAKE

SCALE 0 10 METERS



POWERHOUSE TRANSVERSE SECTION

SCALE 0 10 METERS

NOTE:
BASED ON THE TASHKENT HYDRO DESIGN INSTITUTE (THDI) LAYOUTS.

ARZA ENGINEERING COMPANY AUGUST 1993

KYRGYZSTAN
KYROV POWERPLANT

GENERAL ARRANGEMENT
PLAN VIEWS, PROFILE AND SECTI

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Chapter 7

THE KIROV HYDROELECTRIC PROJECT

7.1 Project Setting

7.1.1 Location

The Kirov Hydroelectric Project will be located at the site of an existing dam and irrigation water storage reservoir. The dam is located on the Talas River in northwestern Kyrgyzstan (See Exhibit 3-1). The reservoir is operated since 1975 for seasonal regulation of water which is used from April to September for downstream irrigation. The reservoir provides seasonal storage for about 105,000 hectares (ha) which include 20,000 ha in Kyrgyzstan and 85,000 ha in Kazakhstan. The hydroelectric project would use the irrigation discharges to produce electric energy.

The Tashkent Hydro Design Institute (THDI) engineers produced in 1988 a "Technic and Economic Calculations" documentation which has the level and scope of a feasibility study. The irrigation dam was built in the Gorge of Tchon-Kopka where Talas River exits the mountainous area, in the rocky formation known as the Itchkel-Tav. The drainage area at the dam section measures 52700 km^2, including some 120 km^2 of eternally snow-covered parts. Total river length is 661 km and the Kirov dam is located at about 150 km from the sources. The site is located in the Talas Region, within the Kirov Township ("Rayon"). Harza has visited the dam and the planned plant site, discussed the project features with the THDI engineers, and reviewed the basic studies and the proposed layout, as well as some alternative project configurations which were developed and analyzed during the feasibility studies. Based on these fact finding and review activities, updated cost estimates were completed for project development.

7.1.2 Topographic Mapping

Topographic maps are available from the previous project activities. The detail and quality of the existing material are adequate and correspond to the current projects status. Topographic maps of the general area of the project and of the site were developed at the scale 1:25,000 (contour intervals at 50 m). Maps at the scale 1:1000 (contour intervals at 1 m), cover proposed layout components and material borrow areas. Existing and future road alignments are presented at 1:2000.The total area surveyed amounts to about 30 ha.

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7.1.3 Geologic and Geotechnical Investigations

Geologic and geotechnical investigations were completed for construction of the original irrigation reservoir and dam, and more recently, as part of the hydroelectric station feasibility study.

The existing dam and reservoir were designed by Kyrgyzhyprovodhoz in Bishkek, and construction was completed in 1975. Mr. Vladomir Alexanderovich Chernetsov was Chief Engineer for the project and met with the Harza team.

Kyrgyzhyprovodhoz conducted initial geological and geotechnical investigations in conjunction with design and construction of the Kirov irrigation reservoir and dam (1963-1964).

The initial geologic map was performed by the Geological Committee of Kyrgyzstan at a scale of 1:100,000. Early geologic research was performed by Credazhyprovodhoz from 1957 to 1959.

The hydroelectric station preliminary design study was conducted by the THDI engineers in 1988, and Credashydroproject supplemented the previously existing data with:

- Additional subsurface exploration and borehole permeability testing;
- Additional laboratory testing; and
- Preparation of a detailed geologic map; and
- Geophysical investigation work.

The geodesic work included photo-theodolitic mapping of the Kirov water reservoir and particularly the location of the proposed water intake and powerhouse structures. Mapping was done at a scale of 1:1000.

The rocks of the Kirov region are of the upper Paleozoic and Quaternary. The upper Proterozoic is represented by intensively deformed and metamorphosed rocks. The sediments were predominately sand with chlorite and serocite shale fragments.

The power tunnel will be excavated in bedrock through the right abutment. The bedrock consists mainly of fine grained chlorite and sericite schists. The rock is fissile and fractures along bedding planes which tend to dip about 80 degrees at a strike of N60W. The strike of the bedrock is nearly parallel to the axis of the dam.

Quaternary alluvial deposits found along the Talas River, are boulders, cobbles and gravel with sand matrix material, and sand lenses. The depth is up to 12 meters.

Permeability of the alluvial deposits is high (30 to 160 m/day). The permeability of the schist bedrock fractures varies from 5 to 0.03 m/day.

There are three distinct zones within the rock mass at the site. The first zone is one of intense weathering 4 to 5 meters deep, with a permeability of 4 to 5 meters/day and a compression strength of 600 kg/cm^2. The second is a zone of partial weathering characterized by stress unloading. Its permeability is 1.65 m/day and the compressive strength amounts to 750 to 800 kg/cm^2. It is found between depths of 5 and 12 meters. The third zone is the bedrock and is found below depths of 12 m; the bedrock is competent and unaffected by superficial weathering or stress release. Its compressive strength reaches 1000 kg/cm^2 and the permeability is 0.03 meters/day.

The alluvial deposits have a density of 2150 kg/m^3. There are predominately larger than sand-sized grains and pebbles. Permeability is 30 to 160 meters per day.

The first 17 meters of the power tunnel are in the first and second zones of the schist. From 17 to 190 meters the power tunnel will be excavated through the massive stable rocks of the third zone. The powerhouse will be situated on firm bedrock.

Construction aggregates have been located downstream of the construction site. Gravel aggregate is available 3 kilometers from the site at the confluence of the Dzhubanbok tributary to the Talas River. Sand and clay is available 5 kilometers from the dam site along the Balasary tributary.

Seismicity of the Kirov Region is 8 points with a relatively low level of seismic activity. Strong earthquakes are repeated with a recurrence interval of 2000 years.

7.1.4 Hydrology

The climate of the area is continental with cool summers and cold winters. July is the warmest month of the year and January is the coldest month. The river waters originate as glaciers and snow deposits.

The Talas River basin lies both in Kyrgyzstan and in Kazakhstan between the ranges of the Kyrgyz Ala-Too in the North and the Talas Ala-Too in the South. The Talas River is formed by the merging of the KaraKol and Uchkotoi Rivers.

Project site hydrology developed by the designers is based on data recorded at the Kirov Station between 1937/38 and 1987/88. The station is close to the dam site. The mean annual runoff at the dam section amounts to 30.6 m^3/s (968 million m^3/yr). From 1975/76, the river regime is altered by the existing dam operation. The period of record between

1975 and 1988 was used to perform energy calculations for the proposed project by the designers. At the site, 60 percent of the annual runoff occurs during the months of April to September, most of it generated by snowmelt. The maximum flood peak of 282 m^3/s was recorded on June 1972 at station Kirov. The daily minimum flow recorded at the same station was 5.28 m^3/s on April 1974.

Recorded flood peaks were analyzed statistically. The 10000-yr design peak of the inflow flood into the reservoir resulted of 425 m^3/s. This value was used in the design of the spillways of the dam.

The average multiannual flow of suspended sediments at the Kirov dam 132,000 tons, or 4.2 kg/s of discharge. About 81% of the annual transport occurs from April to September. The water turbidity during the same period is 0.19 kg/m^3. The average multiannual water turbidity is 0.14 kg/m^3.

7.2 Kirov Hydroelectric Station Description

Two alternatives for location of the powerhouse were evaluated: 1) the right side of the Talas River 400 meters downstream of the dam; and 2) on the left side of the Talas River adjacent to the dam. Alternative 1 was considered the better alternative by THDI.

The layout proposed by the THDI specialists consists of a power intake at the existing dam, a power tunnel through the right bank of the river (partially excavated previously as a water diversion for the existing dam construction), a surface penstock with a manifold trifurcation leading to the indoor, surface, 3-unit powerhouse, a tailrace canal returning turbine discharge to the Talas river, and outdoors switchyard.

The installed capacity of the plant amounts to 21 MW (net design head of 41 m, 3-unit discharge of 59 m^3/s). The average energy production is 69.7 GWh/yr. The proposed layout components (plan views and sections) are presented on Drawing KYR-01.

7.2.1 Dam and Spillway

The existing dam at Kirov is a concrete buttress construction with a structural height of 84 m and a crest length of 260 m. Crest is at El. 888.5 m. At the normal maximum operating El.886.5, total storage created amounts to 540 million m^3 and the live volume, to 537 million m^3. Current minimum operating level for irrigation is at El.833.1 (dead storage of about 3 million m^3).

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The design flood is attenuated in the reservoir to 375 m^3/s. About 225 m^3/s are spilled over a surface overflow spillway (two 5 m-wide openings) with the crest at El.881.5 m. The balance is discharged through two mid-level hollow cone valves 2.2 m diameter each, with a capacity of 75 m^3/s per outlet with reservoir at El.888.5 m. The two openings are also equipped with maintenance/repairs slide gates operated by hydraulic hoists.

7.2.2 Power Intake

The power intake will be located upstream of the dam right abutment. Tunnels will be constructed through the right abutment to the powerhouse located on the right side of the Talas River downstream of the dam. An existing tunnel will be used for part of the distance from the reservoir to the proposed powerhouse.

The power-related waterways located on the right bank of the river, consist of a 383 m-long pressure tunnel, followed by a 290 m-long exposed steel penstock. The first 209 m-long reach of the tunnel is excavated under a 4.6 x 4.6 m horseshoe section, reinforced concrete-lined to an I.D. of 4.0 m. The invert of this tunnel is at El.833.6, 0.5 m above the minimum operating level for irrigations. Consequently, portal excavation can take place only during the months of september/october which follow the irrigation water release season, before reservoir filling starts for the next season (current planning includes five such construction periods during subsequent years). The intake design includes trashracks and maintenance slide gates, operated by hydraulic hoists and a crane. This first tunnel reach intercepts a plugged, existing tunnel (length of 174 m), used to divert water during the construction of the dam. The connection is made through a 15 m-long transition to the existing tunnel with internal dimensions of 5.55 (vertical) x 4.6 (horizontal) m, lined with concrete 35 to 40 cm thick. This tunnel will have to be rehabilitated. Steel liner starts 10 m before day light and connects to the 4.0 m internal diameter exposed steel penstock. The distributor branches have 2.5 m internal diameters. Both penstock and the distributor are installed in an open trench above the flooding line, subsequently filled with gravel. Anchor supports followed by compensators, are provided at the initiation and at all the elbows. The penstock end and the distributor are embedded in concrete (and grouted), and then covered by loose material. The design of the penstock membrane is for internal pressure, with full dynamic head resulting from abrupt maneuvers at the units.

7.2.3 Powerhouse and Equipment

The powerhouse will be located on the right side of the Talas River about 320 meters downstream of the dam. The preliminary design study proposed the use of three equal normalized turbines each having maximum capacity of 7 MW, making the total installed plant capacity 21 MW. The average annual generation amounts to 70 GWh/yr.

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Kirov powerhouse is planned as a 36 m-long, 15.5 m-wide and 25 m-high (including crane) semi-indoor structure. The three generators have individual steel weather-proof covers. The plant includes three unit and one erection bays. Powerhouse foundation is to be excavated in hard sandstones with a maximum pit excavation of 12 m, down to El.815 m. No transverse joints are provided between unit bays or between unit and erection bays. Unit bay width is designed to 7.5 m.

Turbine guard slide gates for emergency and repairs at the units are provided immediately upstream of the powerhouse. The three 4.2 x 5.5 m slide gates are operated by individual hydraulic hoists and a gantry is provided to travel the whole powerhouse length and to span both turbine guard gates and draft tube bulkheads.

The turbines are vertical shaft Francis-type machines. The design machine is a russian axial-radial "Normalized-type" unit under the denomination RO75/728b-V-160, rotating at 300 rpm. Unit installed capacity is 7.3 MW at 41 m net design head. Plant design discharge is 59.1 m^3/s. The runner diameter is 1.6 m. The machine centerline is at EL.821.6 m corresponding to a minimum submergence of 2 m for one turbine operating at 19.7 m^3/s.

The design generator is also an umbrella-type russian machine with air cooling and thirster excitation. Its denomination is SV350/72-20UHL4, rated at 7.0 MW, Other characteristics include Cos fi = 0.8, voltage 10.5 kV, 300 rpm. Generator floor is at El.825.8 m and stator diameter is 2.8 m..

One transformer TD-25000/110 is located on a platform by the powerhouse (El.827.6 m). Unit capacity is 25000 kVA and the voltage is 110/10.5 kV.

7.2.4 Switchyard

The 40 x 30 m outdoor 110 kV switchyard is located on the left bank opposite the powerhouse, at El.828.8 m. About 150 m-long cable connects the powerhouse to the switchyard.

7.2.5 Transmission Interconnection

The Kirov hydroelectric project would be connected to the existing grid through a 6-km transmission line to the 110-kV double circuit Djambul-Kirovka transmission line.

7.2.6 Access Road

A two-lane, hard cover road transitable by heavy trucks and other construction equipment, as well as by city vehicles, is in operation presently and is used to access the existing Kirov dam.

7.2.7 Construction Cost Estimate and Schedule

Chapter 4 describes the approach and methodology used to prepare the cost estimates. The chapter details the bases for labor, materials and construction equipment rates, unit prices, direct and indirect costs, contingencies and total construction cost. A general description of the cost analysis for the major cost items is also presented.

A construction schedule is shown in Exhibit 7-1. This schedule is based on the construction schedule developed by the THDI specialists. However, the total duration of the work has been shortened to 3.5 years from the original 5 years. Total construction cost for the Kirov project is estimated at $ 19.4 million at a March 1993 price level. Table 7-1 shows the estimated construction cost of the project by major item. The detailed cost estimate is presented in Exhibit 7-2.

Table 7-1

KIROV COST ESTIMATE

Item Description		Total in $$
General Items		200,000
Common Excavation		316,680
Rock Excavation		140,630
Tunneling - Intake Tunnel		291,200
Embankments		147,840
Backfill		28,980
Surface Concrete - M 200		2,471,850
Underground - Power Tunnel		871,200
Consolidation Grout		101,400
Contact Grout - Power Intake		7,200
Steel		1,286,818
Mechanical, Electrical, Other		4,210,625
Gates, Cranes, Etc.		1,641,800
Switchyard		1,000,000
Transmission Line (220 kV)		1,524,000
Direct cost Total		14,240,223
Contingency		3,434,424
Subtotal		17,674,647
Engineering and Administration 10%		1,767,465
Project cost total at March 1993 level	**U.S. $**	**19,442,112**

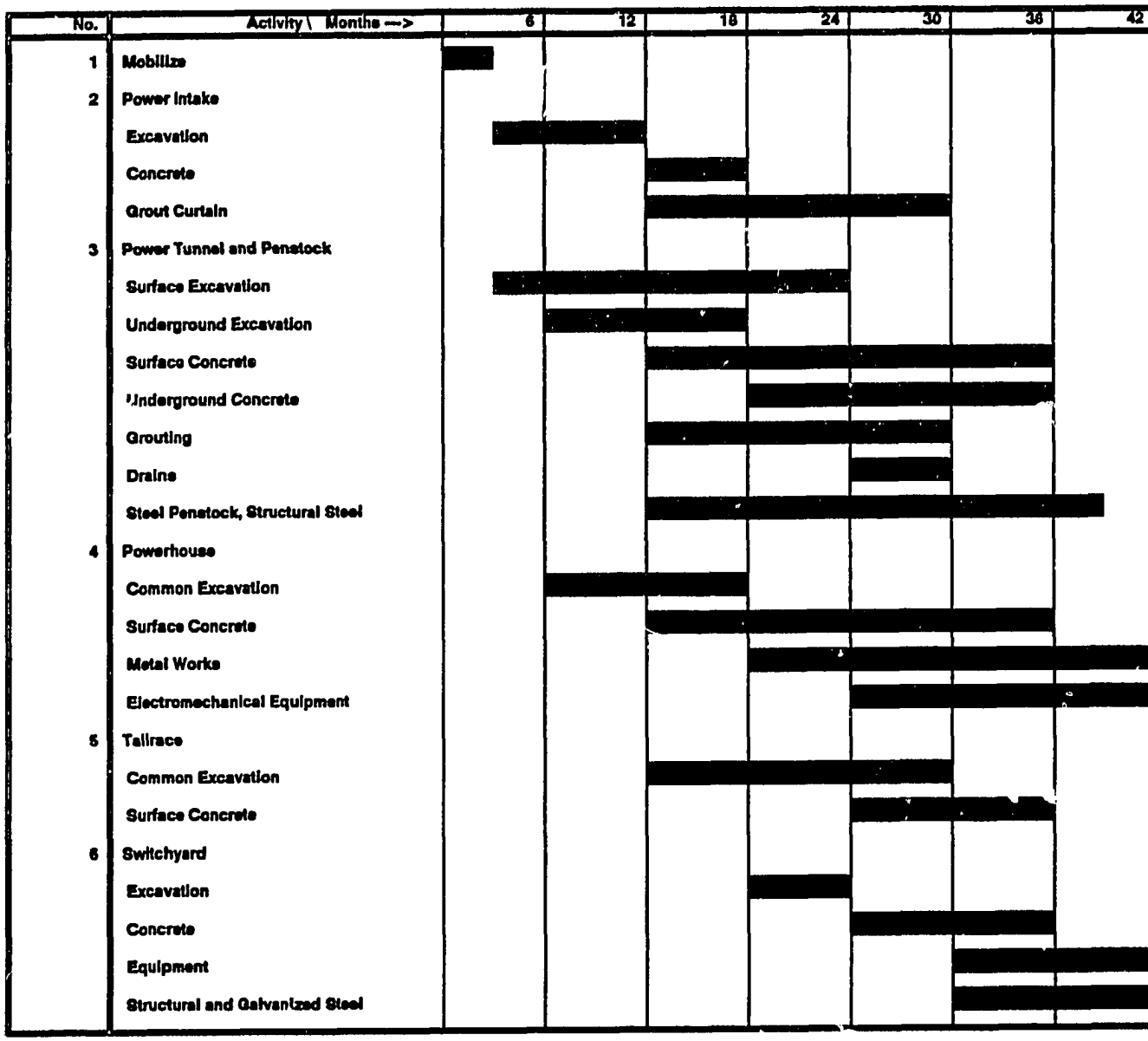
7.3 Alternative Kirov Layout Considerations

The main purpose of reservoir operation at Kirov is water release for irrigations. Unless the irrigation regime can be partially altered, it might be recommendable to analyze lower installed capacities with smaller or fewer units, or at least a staged development in the powerhouse. A left bank development alternative with a smaller installation was analyzed by the THDI engineers at the feasibility level. It proved to be slightly more economically attractive than the larger development. However, the THDI designers have proposed the larger development based on the assumption that most economic parameters, including the price level of local and Russian fossil fuels, will change over time. Harza considers that this adjustment has already become a reality. New economic analyses should be performed for a range of developments. Results of such analyses should narrow the recommended installed capacity range and operating rules at Kirov.

Alternative layouts could also be considered when updating construction costs and economic parameters. An attempt should be made to use the existing construction tunnel in its entirety. Under these conditions, the intake (built at the same invert elevation of 833.6 m) would be placed above the existing tunnel portal (invert at elevation of 825.0 m). An inclined shaft would intercept the existing tunnel. The 6 to 8 m-long shaft, together with the rehabilitation of the 175 m-long upstream reach of the existing tunnel, could cost less than the 209 m-long new tunnel.

10-Sep-93 KIROV PROJECT SCHEDULE

CONSTRUCTION SCHEDULE FOR KIROV HYDRO PROJECT IN KYRGYZSTAN



KIROV PROJECT All Costs in US Dollars

COST ESTIMATE FOR KIROV PROJECT

ITEM DESCRIPTION	TOTAL COST
General	200,000
Common Excavation	316,680
Rock Excavation	140,630
Tunneling - Intake Tunnel	291,200
Embankments	147,840
Backfill	28,980
Surface Concrete - M 200 Concrete	2,471,850
Underground - Power Tunnel	871,200
Consolidation Grout	101,400
Contact Grout - Power Intake	7,200
Steel	1,286,818
Mechanical, Electrical, and Other	4,210,625
Gates, Cranes, Etc.	1,641,800
Switchyard	1,000,000
Transmission Line (220 kV)	1,524,000
Total	14,240,223
Contingency	3,434,424
Total with Contingency	17,674,647
Engineering & Administration	1,767,465
Project Cost at March 1993 Level	19,442,112
All Costs in US Dollars	

KIROV PROJECT

All Costs In US Dollars

COST ESTIMATE FOR KIROV PROJECT

KYRGYZSTAN LABOR RATES, INTERNATIONAL MATERIAL PRICES AND MODIFIED EQUIPMENT RATES, AT MARCH 1993 LEVEL

RANDOM FILL DAM ESTIMATE

Item #	Description		Quantity	Unit	Rate	Total
1	General					
1.1	Mobilization and Demobilization		1	LS	150,000	150,000
1.2	Access Roads		1	LS	25,000	25,000
1.3	Housing and Camp		1	LS	25,000	25,000
	Total Cost Item 1					200,000
2	Total Excavations					
2.1	Common Excavation	Cu M				
2.11	Power Intake	31,200				
2.12	Tailrace	15,000				
2.13	Powerhouse	13,000				
2.14	Miscellaneous	50,000				
	Total Qty	109,200				
	Total Cost Item 2.1		109,200	Cu M	2.90	316,680
2.2	Rock Excavation	Cu M				
2.21	Power Intake	12,100				
2.22	Tailrace	5,000				
2.23	Powerhouse	17,200				
	Total Qty	34,300				
	Total Cost Item 2.2		34,300	Cu M	4.10	140,630
2.3	Tunneling - Intake Tunnel		5,200	Cu M	56	291,200

KIROV PROJECT

All Costs In US Dollars

COST ESTIMATE FOR KIROV PROJECT

KYRGYZSTAN LABOR RATES, INTERNATIONAL MATERIAL PRICES AND MODIFIED EQUIPMENT RATES, AT MARCH 1993 LEVEL

RANDOM FILL DAM ESTIMATE

Item #	Description		Quantity	Unit	Rate	Total
3	Fills					
3.1	Embankments	Cu M				
3.11	Powerhouse	18,500				
3.12	Intake	13,700				
3.13	Switchyard	11,500				
3.14	Miscellaneous	300				
	Total Qty	44,000				
	Total Cost Item 3.1		44,000	Cu M	3.36	147,840
3.2	Backfill		13,800	Cu M	2.10	28,980
4	Surface Concrete - M 200 Concrete	Cu M				
4.1	Power Intake & Tunnel	2,680				
4.2	Powerhouse	9,270				
4.3	Tailrace	4,180				
4.4	Switchyard	680				
4.5	Miscellaneous	1,500				
	Total Qty	18,310				
	Total Cost Item 4		18,310	Cu M	135	2,471,850
5	Underground Concrete - Power Tunnel		3,960	Cu M	220	871,200

KIROV PROJECT

All Costs In US Dollars

COST ESTIMATE FOR KIROV PROJECT

KYRGYZSTAN LABOR RATES, INTERNATIONAL MATERIAL PRICES AND MODIFIED EQUIPMENT RATES, AT MARCH 1993 LEVEL

RANDOM FILL DAM ESTIMATE

Item #	Description		Quantity	Unit	Rate	Total
6	Crout					
6.1	Consolidation Grout	Sq M				
6.11	Power Intake	3,100				
6.12	Miscellaneous	280				
	Total Qty	3,380				
	Total Cost Item 6.1		3,380	Sq M	30	101,400
6.2	Contact Grout - Power Intake		900	Sq M	8	7,200
7	Steel					
7.1	Penstock Steel Liner		523	Tonne	2,062	1,078,426
7.2	Structural Steel		32	Tonne	2,106	67,392
7.3	Galvanized Steel		47	Tonne	3,000	141,000
	Total Cost Item 7					1,286,818

COST ESTIMATE FOR KIROV PROJECT

KYRGYZSTAN LABOR RATES, INTERNATIONAL MATERIAL PRICES AND MODIFIED EQUIPMENT RATES, AT MARCH 1993 LEVEL

RANDOM FILL DAM ESTIMATE

Item #	Description	Quantity	Unit	Rate	Total
8	Mechanical, Electrical, and Other				
8.1	Francis Units 7 MW	3	Ea	639,000	1,917,000
8.2	Transformers	3	Ea	79,875	239,625
8.3	Generators 7 MW	3	Ea	560,000	1,680,000
8.4	Miscellaneous Mech.	1	LS	290,000	290,000
8.5	Miscellaneous Elec.	1	LS	84,000	84,000
	Total Cost Item 7				4,210,625
9	Gates, Cranes, Etc.				
9.1	Gates, Hoists, Etc.	1	LS	641,800	641,800
9.2	Cranes	1	LS	1,000,000	1,000,000
	Total Cost Item 8				1,641,800
10	Switchyard	1	LS	1,000,000	1,000,000
11	Transmission Line (110 kV)	6	Km	254,000	1,524,000
					14,240,223
	Contingency, Civil work	30%			1,759,139
	Contingency, All other work	20%			1,675,285
					17,674,647
	Engineering and Administration	10%			1,767,465
	Total Cost @ March 1993 Level				19,442,112

Chapter 8

HYDRO OPERATION STUDIES AND GENERATION EXPANSION

8.1 Introduction

The results of the power market study presented in chapter 2 were used to develop three scenarios of capacity and energy requirements for the period 1995-2010. Station uses and transmission and distribution losses as well as non-technical losses were taken into account and described in the following paragraphs. Reservoir operation studies performed by the Tashkent Hydro Design Institute (THDI) were reviewed and new runs were performed to test the production of the existing and new hydro projects under a different mode of operation.

An economic analysis was then conducted to evaluate the economic feasibility of the hydroelectric projects presented in chapters 5, 6 and 7 by comparing them to the most likely thermal alternatives. The results were used to develop a generation expansion program.

8.2 Forecasted Peak and Energy Generation

8.2.1 Future Annual Energy Demand

Table 8-1 summarizes the forecasted energy demand which was discussed in chapter 2.

Table 8-1

ANNUAL ENERGY DEMAND SCENARIOS (GWh)

Year	Low Growth	Moderate Growth	High Growth
Total Internal Demand of Kyrgyzstan			
1995	7,320	9,150	10,070
2000	9,590	11,750	15,000
2010	13,350	18,350	24,000
Total Demand With Net Export			
1995	8,820	11,150	13,159
2000	11,090	13,750	16,775
2010	17,730	24,920	30,529

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8.2.2 Future Annual Peak Demand

Table 8-2 summarizes the historical annual peak and energy demand at the customer level for the period 1989-1992.

Table 8-2

HISTORICAL ANNUAL PEAK AND ENERGY DEMAND

Year	Peak Demand (MW)	Energy Demand (GWh)	Load Factor (%)
1989	1,439	7,349	58.3
1990	1,511	7,643	57.7
1991	1,637	8,129	56.7
1992	1,727	8,111	53.6

Table 8-2 shows that the annual load factor has decreased over the past four years, mostly due to the growth of electric heating and residential consumption during the winter months.

For future years, it was not possible to perform a detailed analysis of annual peak demand due to the lack of historical and projected data for each customer group. However, since it is expected that the winter load will continue to grow faster than the remaining load, the annual load factor is assumed to decrease to about 52.5 percent by 1995 and remain at about 50.0 percent for the period 2000-2010. Table 8-3 shows the projected annual peak demand.

Table 8-3

PROJECTED ANNUAL PEAK DEMAND (MW)

Year	Low Growth	Moderate Growth	High Growth
1995	1,590	1,990	2,190
2000	2,190	2,680	3,420
2010	3,050	4,190	5,480

If the annual load factor remains at about 55 percent, the annual peak would be 2,440 MW in 2000 and 3,810 MW in 2010, under the Moderate Growth scenario.

8.2.3 Station Use and System Losses

Table 8-4 summarizes the energy station use and system losses over the past ten years. The results show that station use and system losses vary between 19 and 24 percent of total customer demand with an average of 21.4 percent.

Table 8-4

STATION USE AND SYSTEM LOSSES

Year	Station Use (GWh)	T & D Losses (GWh)	Total (GWh)	Percent of Customer Demand (%)
1983	416	719	1,135	20.9
1984	436	900	1,336	22.6
1985	436	915	1,351	21.7
1986	463	1,057	1,520	23.9
1987	477	873	1,350	20.4
1988	473	1,116	1,589	23.1
1989	503	1,142	1,645	22.4
1990	498	1,035	1,534	20.1
1991	487	1,064	1,551	19.1
1992	405	1,188	1,593	19.6

The energy system losses are high by normal U.S. standards. This is due to the high losses in the distribution system and also non-technical losses such as non-registered customers. Efforts are currently underway to reduce these losses. For future years, it has been assumed that station use and system losses would be about 20 percent in 1995, 18 percent in 2000 and 15 percent in 2010.

The peak power generation was 1,790 MW in 1991 and 1,850 MW in 1992. By comparison, the customer peak demand was 1,637 MW in 1991 and 1,727 MW in 1992. Losses were between 7 and 9 percent. For future years, it has been assumed that peak losses would be about 8 percent in 1995 and 2000 and 7 percent in 2010.

8.2.4 Future Annual Energy Generation

Table 8-5 summarizes the forecasted energy generation. The data presented in that table is derived from the data shown in Table 8-1 and the estimated station use and system losses discussed in the preceding section.

Table 8-5

ANNUAL ENERGY GENERATION SCENARIOS (GWh)

Year	Low Growth	Moderate Growth	High Growth
Total Internal Demand of Kyrgyzstan			
1995	8,800	11,000	12,100
2000	11,300	13,850	17,700
2010	15,350	21,100	27,600
Total Demand With Export			
1995	10,600	13,400	15,800
2000	13,100	16,200	19,800
2010	20,400	28,650	35,100

8.2.5 Future Annual Peak Generation

Table 8-6 shows the projected annual peak generation.

Table 8-6

PROJECTED ANNUAL PEAK GENERATION (MW)

Year	Low Growth	Moderate Growth	High Growth
1995	1,720	2,150	2,370
2000	2,370	2,890	3,690
2010	3,260	4,480	5,860

8.2.6 Monthly Distribution of Peak and Energy Generation

An analysis of historical monthly energy generation was done. The data for 1991 and 1992 is shown on Table 8-7 and Exhibits 8-1 and 8-2.

Table 8-7

HISTORICAL MONTHLY DISTRIBUTION OF PEAK AND ENERGY GENERATION

Year	Month	Energy (GWh)	Peak (MW)	Load Factor (%)
1991	January	982	1,790	73.7
	February	888	1,739	75.9
	March	896	1,702	70.8
	April	807	1,458	76.9
	May	738	1,343	73.9
	June	711	1,310	75.4
	July	713	1,264	75.8
	August	711	1,263	75.7
	September	692	1,326	72.4
	October	747	1,496	67.1
	November	839	1,610	72.4
	December	957	1,694	76.0
	Annual	9,681	1,790	61.7
1992	January	1,014	1,722	79.2
	February	911	1,646	82.3
	March	948	1,669	76.4
	April	771	1,566	68.4
	May	731	1,472	66.7
	June	685	1,274	74.6
	July	663	1,189	75.0
	August	656	1,228	71.7
	September	652	1,333	67.9
	October	667	1,460	61.4
	November	900	1,635	76.5
	December	1,064	1,850	77.3
	Annual	9,660	1,850	59.6

The peak demand is during the winter peak months of November through March. The summer demand is about 70 percent of the winter demand. Exhibits 8-3 and 8-4 show the 1991 and 1992 monthly peak and energy demand as a percentage of the total annual demand. These results were used to forecast future monthly peak and energy demand. This

monthly breakdown is required as an input to the hydropower operation studies described later. As described in chapter 2, the winter load has sharply increased over the past two years and this trend is expected to continue. Table 8-8 shows the assumed monthly breakdown for the period 1995-2000.

Table 8-8

FUTURE MONTHLY DISTRIBUTION OF PEAK AND ENERGY GENERATION

Month	Energy (% of Annual)	Peak (% of Annual)
January	12.5	100
February	10.5	95
March	9.5	90
April	8.0	85
May	7.0	80
June	6.0	60
July	6.0	55
August	5.5	55
September	6.0	65
October	6.5	80
November	10.0	90
December	12.5	100

8.3 Hydropower Operation Studies

Hydropower operation studies were performed to estimate long-term dependable and average monthly and annual energy generation associated with project layout and operation alternatives. Operation studies were performed for the existing projects: Toktogul, Kurpsai, Tashkumyr, Shamaldysai, and Uch-Kurgan and for the new potential projects: Kambarata 1 and 2 projects. The results of these operation studies were used as input to the economic analysis and expansion program presented in the following sections of the chapter.

Input data such as monthly flows, evaporation, reservoir area-volume curves, tailwater rating curves and powerplant performance data were provided by the THDI.

8.3.1 Operating Criteria

The major existing hydroelectric powerplants are located in the Lower Naryn downstream of the Toktogul reservoir. The primary purpose of the Toktogul reservoir has been to provide multi-annual and seasonal storage for irrigation releases for Uzbekistan and Kazakstan. Water is stored behind the Toktogul reservoir for summer releases to meet irrigation demand in Uzbekistan and Kazakstan. The projects downstream of Toktogul do not have seasonal storage and are used for daily peaking. Power and energy is generated as the by-product of irrigation release. As a result there is great amount of generation in the summer months in excess of the internal demand of Kyrgyzstan. Within the former Soviet Union, this excess was used in the other republics of Central Asia through the 500-kV transmission network. In the winter when water was conserved for the summer irrigation requirements, power would flow back from the other Central Asian republics into Kyrgyzstan to meet the winter load of Kyrgyzstan. A regional balance and optimization of water for power and irrigation was achieved. Today, a new political and economic situation exists and a new balance needs to be achieved.

A series of new operation runs were made to evaluate the operation of these projects as primarily power projects with only a constant minimum release of 100 m^3/s for downstream requirements. This is only a theoretical scenario to evaluate the output of existing and future projects if they were to meet the electrical power demand of Kyrgyzstan as a first priority. Instead of storing water for summer irrigation release, the water is being stored for winter release when the demand for electricity is maximum.

For both cases, the Kambarata projects located upstream of the Toktogul reservoirs are operated for power only since the release from these projects can be stored and regulated in the Toktogul reservoir.

8.3.2 Results

Under the first scenario which assumes that the projects are operated for irrigation purposes as a first priority, the power and energy generation was computed by the THDI specialists during the feasibility studies. The results are summarized in Tables 8-9, 8-10 and 8-11. Details are presented in Exhibits 8-5 through 8-12.

Table 8-9 presents the expected monthly and annual energy generation for the existing projects assuming full operation of the two projects which are being completed. The generation data shown in the 10, 50 and 90 percent columns represent the energy generation at these probability levels. The 90 percent corresponds to the dependable or firm energy generation. The results show that the energy generation during the months of July and August is more than three and a half times the generation in December or January.

HYDROPOWER ENERGY GENERATION (MWh)
IRRIGATION SCENARIO

TOKTOGUL/KURPSAI/TASHKUMYR/SHAMALDYSAI/UCH-KURGAN PROJECTS

MONTH	EXCEEDENCE LEVEL			AVERAGE
	10%	50%	90%	
January	781,051	463,214	411,506	513,011
February	828,106	511,056	461,866	577,147
March	716,621	688,646	616,330	664,186
April	563,328	515,520	440,496	503,062
May	975,161	610,898	510,905	685,397
June	2,059,776	1,099,726	710,352	1,268,517
July	2,129,551	1,713,878	1,256,616	1,700,819
August	2,129,700	1,758,616	1,308,175	1,740,567
September	1,030,606	719,856	581,112	757,072
October	707,916	477,053	407,340	512,345
November	600,768	452,520	392,688	468,322
December	882,310	461,354	405,108	511,758
ANNUAL	12,505,937	9,727,073	7,933,135	9,902,203

Table 8-10
HYDROPOWER ENERGY GENERATION (MWh)
IRRIGATION SCENARIO

KAMBARATA 2/TOKTOGUL/KURPSAI/TASHKUMYR/SHAMALDYSAI/UCH-KURGAN PROJECTS

MONTH	EXCEEDENCE LEVEL			AVERAGE
	10%	50%	90%	
January	914,897	595,051	539,995	642,440
February	963,446	638,131	581,685	698,870
March	765,502	734,849	659,110	709,974
April	563,328	515,520	440,496	503,062
May	975,161	610,898	510,905	689,225
June	2,311,128	1,205,856	710,352	1,383,199
July	2,389,579	1,913,717	1,380,343	1,893,058
August	2,367,482	1,919,818	1,430,786	1,907,441
September	1,159,992	804,024	648,288	847,375
October	781,646	533,746	453,691	570,367
November	674,136	525,816	465,840	542,017
December	1,043,014	619,454	561,125	670,882
ANNUAL	13,924,565	10,857,134	8,855,042	11,057,911

Table 8-11
HYDROPOWER ENERGY GENERATION (MWh)
IRRIGATION SCENARIO

KAMBARATA 1/KAMBARATA 2/TOKTOGUL/KURPSAI/TASHKUMYR/SHAMALDYSAI/UCH-KURGAN PROJECTS

MONTH	EXCEEDENCE LEVEL			AVERAGE
	10%	50%	90%	
January	1,469,772	1,145,537	1,078,577	1,177,345
February	1,445,606	1,111,018	1,049,856	1,146,113
March	920,477	887,294	806,868	860,160
April	563,328	515,520	440,496	503,062
May	975,161	610,898	510,905	706,465
June	3,662,784	1,693,296	710,352	1,944,601
July	3,786,365	2,680,173	1,965,499	2,641,376
August	3,520,236	2,693,652	2,012,446	2,712,221
September	1,759,464	1,198,080	959,976	1,270,137
October	1,120,762	789,384	659,705	831,870
November	1,010,592	862,128	793,080	876,890
December	1,777,193	1,349,318	1,264,367	1,393,373
ANNUAL	20,660,566	15,801,271	12,960,226	16,263,613

Table 8-10 presents the expected monthly and annual energy generation for the existing projects and Kambarata 2. Table 8-11 presents similar results including Kambarata 1 and 2. With the Kambarata 1 project, the winter generation greatly increases.

Under the second scenario which assumes that the projects are operated for power and energy generation purposes as a first priority, the power and energy generation was computed by Harza using an in-house reservoir operation program. The results are summarized in Tables 8-12, 8-13 and 8-14. Details are presented in Exhibits 8-13 through 8-20.

Table 8-12 presents the expected monthly and annual energy generation for the existing projects assuming full operation of the two projects (Tashkumir and Shamaldisai) which are being completed. The results can be compared to the data shown in Table 8-9. Under this second scenario, the energy generation during the winter months is about three and a half times the energy generated under the first scenario. On the other hand, the energy generation during the summer months is only about 25 percent of the energy generated under the first scenario.

Table 8-13 presents the expected monthly and annual energy generation for the existing projects and Kambarata 2. Table 8-14 presents similar results including Kambarata 1 and 2 projects. The data presented in these two tables can be compared to the data presented in Table 8-10 and 8-11. Under this second scenario, the hydro energy is mostly generated during the winter months to meet the electrical demand.

Exhibit 8-21 shows graphically the results of monthly energy generation from the existing projects (Toktogul and the downstream projects) under both scenarios. Exhibit 8-22 shows similar graphs with the addition of the Kambarata 1 and 2 projects. The average and dependable monthly energy generation is shown on both Exhibits.

With the collapse of the former Soviet Union, new agreements are being negotiated between the various Central Asia republics to meet both the irrigation and electricity requirements. At the present time, there are only firm agreements for the next three- and six-month periods. With the current review of the irrigation sector and cropping patterns in Uzbekistan and Kazakstan and the environmental issues associated with the Aral Sea, it is expected that major changes will occur in water appropriations in the near future. For the purposes of our economic analysis and expansion program, it has been assumed that there will be a greater optimization and efficiency of water uses for irrigation allowing more water to be stored for electricity generation during the winter months. At the same time, it is expected that power exchanges will resume between the various republics to balance the excess hydro-electricity generation in summer due to irrigation demand with thermal exports to Kyrgyzstan to meet the internal electricity demand of Kyrgyzstan during the winter months. A compromise between the two scenarios presented in Exhibits 8-5 through 8-22 will be achieved and hydro capacity and energy "lost" to irrigation will be compensated with

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POWER ONLY SCENARIO

TOKTOGUL/KURPSAI/TASHKUMYR/SHAMALDYSAI/UCH-KURGAN PROJECTS

MONTH	EXCEEDENCE LEVEL 10%	50%	90%	AVERAGE
January	1,678,300	1,557,300	1,520,900	1,575,000
February	1,199,920	1,109,180	1,071,760	1,125,150
March	1,106,650	996,260	958,950	1,016,140
April	1,068,510	863,620	798,090	892,270
May	1,282,000	792,120	712,730	878,470
June	2,227,700	659,160	561,990	1,023,660
July	1,443,800	445,760	406,920	659,340
August	929,980	414,640	389,590	561,640
September	857,080	521,620	501,660	574,020
October	799,020	620,430	591,690	650,720
November	1,186,920	1,068,210	1,046,290	1,106,840
December	1,652,600	1,547,500	1,507,100	1,562,200
ANNUAL	14,574,900	10,831,570	10,135,950	11,625,450

Table 8-13
HYDROPOWER ENERGY GENERATION (MWh)
POWER ONLY SCENARIO

KAMBARATA 2/TOKTOGUL/KURPSAI/TASHKUMYR/SHAMALDYSAI/UCH-KURGAN PROJECTS

MONTH	EXCEEDENCE LEVEL 10%	50%	90%	AVERAGE
January	1,729,850	1,600,300	1,557,150	1,617,840
February	1,246,240	1,147,090	1,104,730	1,164,300
March	1,163,770	1,044,390	999,590	1,064,050
April	1,191,110	935,790	846,070	965,460
May	1,512,900	945,220	817,130	1,039,470
June	2,487,100	898,160	702,890	1,242,760
July	1,711,000	661,960	562,220	872,640
August	1,169,680	575,140	520,590	729,140
September	963,180	606,610	572,160	664,050
October	878,100	682,420	645,540	714,710
November	1,248,470	1,140,000	1,091,040	1,159,730
December	1,709,720	1,591,490	1,544,610	1,608,250
ANNUAL	16,082,340	12,016,740	11,104,870	12,842,400

Table 8-14
HYDROPOWER ENERGY GENERATION (MWh)
POWER ONLY SCENARIO

KAMBARATA 1/KAMBARATA 2/TOKTOGUL/KURPSAI/TASHKUMYR/SHAMALDYSAI/UCH-KURGAN PROJECTS

MONTH	EXCEEDENCE LEVEL 10%	50%	90%	AVERAGE
January	2,013,800	1,821,090	1,766,720	1,855,700
February	1,788,300	1,601,910	1,564,710	1,637,940
March	1,636,420	1,464,640	1,431,340	1,491,520
April	1,648,050	1,256,530	1,168,310	1,316,770
May	2,013,600	1,237,510	1,154,360	1,400,070
June	3,745,500	1,615,960	942,690	1,896,150
July	2,769,000	1,223,930	835,610	1,455,630
August	1,991,820	1,061,830	818,920	1,226,920
September	1,496,630	941,670	660,820	973,520
October	1,259,350	1,063,690	773,380	1,011,390
November	1,783,600	1,592,640	1,556,150	1,626,290
December	2,093,700	1,891,000	1,853,940	1,928,400
ANNUAL	22,795,170	16,880,460	15,197,200	17,826,300

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thermal imports.

8.4 Derivation of Hydro Capacity and Energy Values

8.4.1 Definition of Hydro Dependable Capacity

Unlike thermal power plants which can provide a rated output over any period of time outside planned or forced outages, the output of a hydropower plant is dependent upon available streamflow and reservoir storage. For these reasons, the term "dependable" capacity was developed to provide a measure of the amount of power that a hydropower project can deliver with some degree of reliability, equivalent to the thermal capacity that a hydropower project can displace.

In a power system where hydropower is the dominant resource like in Kyrgyzstan, a conservative approach must be taken to define dependable capacity, because if a drought occurs, the output of most of the system's generating resources could be affected. As a results, the dependable capacity is based on the plant's capability in a high demand month near the end of the reservoir's critical drawdown period. Since the peak demand occurs in winter, the project dependable capacity is defined as the January dependable capacity. A 90 percent exceedence level was used to compute the dependable capacity.

8.4.2 Computation of Hydro Capacity and Energy Values

Large Reservoir Projects (Kambarata 1 and 2) - Dependable Capacity Value. The thermal alternative was assumed to be a Combined Cycle - Gas Turbine (CCGT) power plant, with a construction cost of $750 per installed kilowatt.

The construction period is assumed to be two years with expenditures of 50 percent each year.

The thermal equivalent capacity used in the economic analysis is equal to the hydro dependable capacity times an adjustment factor which reflects the greater availability of hydro compared to thermal. The adjustment factor is equal to:

$$\frac{(1 - FOR\{hydro\}) \times (1 - SOR\{hydro\})}{(1 - FOR\{CCGT\}) \times (1 - SOR\{CCGT\})}$$

with FOR{hydro} = Hydro Forced Outage equal to 2.0 percent
SOR{hydro} = Hydro Scheduled Outage equal to 14 days per year or 3.8 percent

FOR{CCGT}	=	CCGT Forced Outage equal to 8.0 percent
SOR{CCGT}	=	CCGT Scheduled Outage equal to 21 days per year or 5.7 percent

For CCGT, the adjustment factor is equal to 1.087. The equivalent thermal capacity cost is therefore equal to the hydro net dependable capacity times the adjustment factor times the construction cost.

Fixed O&M costs are estimated at $15 per kilowatt-year for CCGT, and $10 for hydro.

Large Reservoir Projects (Kambarata 1 and 2) - Energy Value. The value of the energy is directly associated with the thermal alternative used for the computation of the capacity value. In our case, it is associated with CCGT.

Based on a gas fuel price of $4.0 per million Btu and an average heat rate of 7,500 Btu per kilowatt-hour, the energy value is estimated at $0.030 per kilowatt-hour.

Variable O&M costs are estimated at $0.0035 per kilowatt-hour.

Kambarata 2 Initial Phase - Dependable Capacity Value. The thermal alternative was assumed to be a coal-fired powerplant, with a construction cost of $1,300 per installed kilowatt.

The construction period is assumed to be four years with an expenditure of 5 percent the first year, 25 percent the second, 45 percent the third, and 25 percent the fourth year.

To reflect higher hydro availability, an adjustment factor was computed. This adjustment factor is equal to:

$$\frac{(1 - FOR\{hydro\}) \times (1 - SOR\{hydro\})}{(1 - FOR\{coal\}) \times (1 - SOR\{coal\})}$$

with	FOR{hydro}	=	Hydro Forced Outage equal to 2.0 percent
	SOR{hydro}	=	Hydro Scheduled Outage equal to 15 days per year or 3.8 percent
	FOR{coal}	=	Coal Forced Outage equal to 10.0 percent
	SOR{coal}	=	Coal Scheduled Outage equal to 45 days per year or 12.3 percent

For coal, the adjustment factor is equal to 1.237. The equivalent thermal capacity cost is therefore equal to the hydro net dependable capacity times the adjustment factor times the construction cost.

Fixed O&M costs are estimated at $25 per kilowatt-year and $10 per kilowatt-year for hydro.

Kambarata 2 Initial Phase - Energy Value. The annual hydro energy generated by the project was divided into two components. The first energy component corresponds to base-load generation and is equivalent to the energy generated from the thermal dependable capacity. The second component corresponds to daily peaking generation and is equal to the remaining energy available. The energy value of the first component was based on coal-fired energy value. The energy value of the second component was based on combined cycle gas turbine energy value.

The energy value of coal generation is computed at $0.020 per kilowatt-hour, based on a coal price of $2.0 per million Btu and a net average heat rate of 10,000 Btu per kilowatt-hour. Variable O&M costs are estimated at $0.0025 per kilowatt-hour.

The energy value of combined cycle gas turbine is computed at $0.030 per kilowatt-hour, based on a gas price of $4.0 per million Btu and a net average heat rate of 7,500 Btu per kilowatt-hour.

Kirov and Upper Naryn Projects - Dependable Capacity Value. The thermal alternative was assumed to be a coal-fired powerplant, with a construction cost of $1,600 per installed kilowatt.

The construction period is assumed to be four years with an expenditure of 5 percent the first year, 25 percent the second, 45 percent the third, and 25 percent the fourth year.

To reflect higher hydro availability, an adjustment factor was computed. This adjustment factor is equal to:

$$\frac{(1 - FOR\{hydro\}) \times (1 - SOR\{hydro\})}{(1 - FOR\{coal\}) \times (1 - SOR\{coal\})}$$

with	FOR{hydro}	=	Hydro Forced Outage equal to 2.0 percent
	SOR{hydro}	=	Hydro Scheduled Outage equal to 15 days per year or 3.8 percent
	FOR{coal}	=	Coal Forced Outage equal to 10.0 percent
	SOR{coal}	=	Coal Scheduled Outage equal to 45 days per year or 12.3 percent

For coal, the adjustment factor is equal to 1.237. The equivalent thermal capacity cost is therefore equal to the hydro net dependable capacity times the adjustment factor times the construction cost.

Fixed O&M costs are estimated at $30 per kilowatt-year and $10 per kilowatt-year for hydro.

Kirov and Upper Naryn Projects - Energy Value. For the Kirov project, the energy value was computed based on energy value of coal-fired generation. The operation of the project is tied to constant irrigation releases and would not follow fluctuations of power demand.

For the Upper Naryn projects, the annual hydro energy generated by the project was divided into two components. The first energy component corresponds to base-load generation and is equivalent to the energy generated from the thermal dependable capacity. The second component corresponds to daily peaking generation and is equal to the remaining energy available. The energy value of the first component was based on coal-fired energy value. The energy value of the second component was based on gas turbine energy value.

The energy value of coal generation is computed at at $0.025 per kilowatt-hour, based on a coal price of $2.5 per million Btu and a net average heat rate of 10,000 Btu per kilowatt-hour. Variable O&M costs are estimated at $0.0030 per kilowatt-hour.

The energy value of gas turbine is computed at $0.060 per kilowatt-hour, based on a gas price of $5.0 per million Btu and a net average heat rate of 12,000 Btu per kilowatt-hour.

8.4 Economic Analysis

An economic analysis was conducted to justify the economic feasibility of the hydroelectric projects by comparing them to the most likely thermal alternatives. The results of the hydropower operation studies presented earlier were used as input to the economic analysis. Other economic parameters and assumptions are described in the following paragraphs.

Construction and operation costs of both the hydro and thermal projects were estimated, based on international prices and adjusted for local conditions. The thermal costs used in this economic analysis are also representative of costs of new thermal powerplants in Kazakhstan and Uzbekistan. Therefore, the conclusions derived from this analysis provide an estimate of the economic attractiveness of the Kyrgyz hydropower projects with new thermal powerplants in Kazakhstan and Uzbekistan.

8.4.1 Economic Assumptions and Criteria

Various methods are commonly used to optimize and to evaluate development projects. Such methods include the computation of the benefit-cost ratio (B/C ratio), the equalizing discount rate (EDR) also called the Internal Rate of Return (IRR), and the net benefit (NB). For each method, a stream of annual costs and benefits are compared, taking into

account the time value of money.

In order to conduct the comparisons it is necessary to express the costs and benefits in common terms. The costs and benefits occurring over the life of the project can be "levelized" through discounting to annual equivalents, or both can be reduced to present worth (PW) using appropriate discount rates.

The B/C ratio can be computed from the PW or by the levelized method. The B/C ratio is equal to the ratio of the present worth of benefits over the present worth of costs, or to the levelized annual benefits over the levelized annual costs, at a specified discount rate. The NB is the difference between the benefits and the costs, at a specified discount rate. The EDR is the discount rate at which the present value of costs equals the present value of benefits. The EDR method is used by private developers because it gives an estimate of the expected financial rate of return and can be compared to rates of return on alternative investments available to them.

For the present analysis, the "World Bank" method using a 50-year economic period was used. No inflation or interest during construction was used. The capacity and energy revenues were maintained at the 1993 price level.

Table 8-15 summarizes the economic criteria used in the analysis.

Table 8-15

ECONOMIC CRITERIA

Reference Year:	1993
Discount Rate:	12.0 percent
Inflation Rate:	0.0 percent
Economic Life:	
Hydro:	50 years
CCGT:	20 years
Coal:	30 years

A spreadsheet was developed to perform the economic analysis. Tables 8-16 and 8-17 present input data for the thermal and hydro alternatives.

Table 8-16

ECONOMIC ANALYSIS - INPUT DATA FOR THERMAL GENERATION

	Large Projects		Small Projects	
	Coal-Fired	CCGT	Coal-Fired	GT
Construction Cost ($/kW)	1,300	750	1,600	500
Fixed O&M Cost ($/kW/year)	25	15	30	25
Variable O&M Cost ($/MWh)	2.5	3.5	3.0	5.0
Type of Fuel	Coal	Gas	Coal	Gas
Price of Fuel ($/MBtu)	2.0	4.0	2.5	5.0
Energy Value ($/MWh)	20	30	25	60
Construction Period	4	2	4	1

8.4.2 Results of the Economic Analysis

Exhibits 8-23 through 8-34 present the cumulative present worth of each hydropower project and its thermal alternative, using a 12 percent discount rate. The equalizing discount rate is also computed and shown on the Exhibits. Table 8-18 summarizes the results.

Table 8-17
ECONOMIC ANALYSIS - INPUT DATA OF HYDRO PROJECTS

Project Name	K2	K2	K1	Kirov	Dzhanykel	Naryn 1	Naryn 2	Naryn 3	Akbulun	Oruktam 1	Oruktam 2	Echinaryn
Project Type	ROR	Peaking	Peaking	ROR	Peaking	ROR	ROR	ROR	ROR	Peaking	Peaking	ROR
Installed Capacity (MW)	240	360	1900	21	130	62	60	60	100	60	48	9.5
Dependable Capacity (MW)	48	210	1300	0	48	14	15	17	24	40	43	8.4
Energy Generation (GWh)	1072	1148	5164	70	470	227	235	254	372	254	259	49.7
Construction Cost (million $)	230.7	260.7	1675.4	19.4	176.5	93.4	100	115	135	180	180	37.5

Construction Cost Expenditures (%)

Year												
1	30	30	5	20	10	15	15	15	15	15	15	25
2	50	50	10	25	20	30	30	30	30	30	30	50
3	20	20	10	35	30	35	35	35	35	35	35	25
4			15	20	25	20	20	20	20	20	20	
5			25		15							
6			20									
7			10									
8			5									

Table 8-18

RESULTS OF THE ECONOMIC ANALYSIS

Project Name	Discount Rate of 12% Cumulative Present Worth Hydro ($*1000)	Thermal ($*1000)	Benefit -Cost Ratio	Equalizing Discount Rate (%)
Kambarata 2: 2 units	160,497	203,009	1.26	16.3
Kambarata 2: 3 units	185,551	311,944	1.68	26.2
Kambarata 1: Blast Dam	822,761	1,032,343	1.25	15.9
Kambarata 1: Arch Dam	897,866	976,865	1.09	13.4
Kirov	12,578	12,244	0.97	11.6
Oruktam 1	110,350	832622	0.75	7.3
Oruktam 2	109,846	87,852	0.80	8.1
Echinaryn	24,427	17,958	0.74	7.1
Dzhanikel	104,519	115,980	1.11	14.0
Akbulun	85,076	102,420	1.20	15.2
Naryn 1	60,612	62,479	1.03	12.5
Naryn 2	62,427	64,696	1.04	12.5
Naryn 3	71,413	69,951	0.98	11.7

The Kambarata 2 project was analyzed under two modes of development. The first mode of development assumes an initial phase with two units and an installed capacity of 240 MW due to the potential postponement of the upstream Kambarata 1 storage project. The second mode of development assumes that the Kambarata 1 project will be built shortly thereafter and the Kambarata 2 project has three units with an installed capacity of 360 MW. The Kambarata 2 project shows an attractive benefit-cost (B/C) ratio under both alternatives: 1.26 and 1.68, respectively, using a 12 percent discount rate. The corresponding equalizing discount rates (rate of return) are 16.3 and 26.2 percent, respectively.

The Kambarata 1 project is also economically attractive with a B/C ratio of 1.25 and an equalizing discount rate of 15.9 percent for the controlled blast dam alternative, and a B/C ratio of 1.09 and an equalizing discount rate of 13.4 percent for the arch dam alternative. The Kambarata 1 project would also provide additional firm and secondary power and energy benefits to the Kambarata 2 project, which would further increase the economic attractiveness of the project.

The Kirov project is marginally attractive with a B/C ratio of 0.97 and an equalizing discount rate of 11.6 percent. The Upper Naryn projects have B/C ratios varying between

0.74 and 1.20. Construction costs of these projects should be refined and a more detailed analysis of alternative thermal generation costs to provide electricity in the areas surrounding these hydropower projects should be performed.

8.5 Hydro Expansion Program

Exhibit 8-35 shows the demand and supply under the moderate growth scenario with and without exports. In addition to the existing thermal and hydro facilities, only the Kambarata 1 and 2 projects have been added. The other hydro projects reviewed in this study are not economically attractive. For the existing thermal facilities, it was assumed that their generation output would be associated with the current district heating requirements without any expansion. KSEC's thermal program is reviewed in the following section. Table 8-19 summarizes the expected monthly electricity generation associated with the two thermal powerplants. It is based on the average electricity generation of the years 1989-91.

Table 8-19

MONTHLY THERMAL ENERGY GENERATION (MWh)

Month	Thermal Energy
January	400,000
February	350,000
March	350,000
April	325,000
May	300,000
June	275,000
July	275,000
August	275,000
September	300,000
October	350,000
November	350,000
December	400,000

Exhibits 8-36 and 8-37 show the monthly details for year 2000 and 2005. Average and dependable hydropower generation is shown for both operation scenarios (irrigation and power only).

Exhibits 8-38 and 8-39 compare the three demand scenarios with supply based on average and firm hydropower energy, respectively.

An analysis of these Exhibits indicate that additional generation is required by the end of the 1990's if Kyrgyzstan wants to continue meeting their export market and even their own internal demand under drought conditions. Since the Kambarata 2 project is already under construction and shows a very attractive benefit-cost ratio, the Kambarata 2 project should be the next project to be completed. Then, depending on the assumptions made on future demand within Kyrgyzstan and the amount of energy that can be exported from Kyrgyzstan, the Kambarata 1 project would need to be in operation sometimes during the next decade.

There are a series of other potential projects that have been studied by the THDI which are located between the Kambarata projects and the Upper Naryn projects. According to their preliminary investigations, these projects are not as economically attractive as the Kambarata 1 and 2 projects but have unit construction costs much lower than the Upper Naryn projects. These projects should be investigated as the next expansion phase after the Kambarata projects.

8.6 Thermal Expansion Program

During the performance of our study, a preliminary review of the thermal powerplants and expansion options was done. The following paragraphs summarizes the results of our investigations.

8.6.1 Bishkek No. 1

Although KSEC has planned to retire the turbine and boiler units when they reach the end of their useful lives which is normally 250,000 hours of operation, this station has several options:

Several of its older turbines and boilers can undergo life extension through rehabilitation;

Introduction of modern instrumentation and controls;

Supplying enough good quality imported coal to replace the present and planned use of fuel oil and gas. Especially this gas can be used more economically and efficiently in a combined cycle unit at the planned Bishkek 2. Nearly 2.3 million of tons of coal per year is required for this option.

Addition of several gas turbines to improve the utilization of natural gas while providing for increased electricity production at high efficiency (approximately, 60%). The waste heat from the gas turbines will produce steam consistent with the existing steam parameters. This steam will be supplied to the existing common steam

header. The header, which is also connected to all the existing steam boilers, distributes the steam to all the operating steam turbines. This increased capacity can be used to supply electricity for heating of houses and buildings which are not integrated into the district heating system. Site limitations may prevent this repowering option.

A detailed feasibility study is required to quantify the economic benefits of implementing each of the above options.

8.6.2 Bishkek No.2

Under the former Soviet Union, KSEC was designing Bishkek Power and Heating Station 2. When completed, this station was expected to have an electric generating capacity of 720 MW, comprised of four 180 MW turbine generators, each of which will be able to supply nearly 260 gigacalories of thermal energy. This station was designed to use natural gas as fuel. The heating network of this station would have been integrated with the heating network of Bishkek unit 1. The estimated gross heat rate for electricity generation was expected to be 1442 kcal/kWhr.

The original plan was designed prior to the breakup of the Soviet Union when the price of natural gas was very low. The other economic parameters used to optimize the plant cycle, plant cost and district heating system design and its capital requirements were very different from those used in free market countries.

If the plant were to be designed today using economic parameters consistent with free market principles which the Republic of Kyrgizstan has opted to follow, the plant size, the plant cycle and district heating system design may or will change substantially. Therefore, it is strongly recommended that a new feasibility study be done based on this new set of rules and using total system approach that includes the existing Bishkek 1 station, co-production of electricity, use of electricity within parts of Bishkek for heating and reliability of supply in the utilization of natural gas and imported coal.

It may be prudent to reexamine the existing design and compare it to building an efficient gas turbine combined cycle district heating plant. Since there are plans to integrate the heating networks of both stations in Bishkek, a total system approach should be used to determine the capacity of this new plant, based on the economic utilization of natural gas. It may be economical to use this increased electric generating capacity of this combined cycle cogeneration unit to displace fossil fuels especially imported coals used in the heating of homes and buildings which have no access to centralized district heating systems. Also, the KSCE plans to build a district heating system in Karakol district to supply nearly 500 gigacalories of thermal energy by the end of 2010. Instead, it may be economically feasible

to supply this energy through the increased electric capacity at the new Bishkek Station and several other planned hydro facilities.

The characteristics of a Combined Cycle Unit for Bishkek 2 would be as follows:

Heating Duty: 260 gcal/hr.
Heating Water Temperatures as for a direct heating system - (180F/125F)
Heating duty should be generated by using a steam turbine extraction. The present design has two low pressure extractions but, because of the preliminary nature of this study, single extractionhas been assumed and this should have negligible impact on the results.

Steam for the steam turbine should be produced in a heat recovery steam generator utilizing exhaust from gas turbines.

Heat Recovery Steam Generator:

HP pinch point temp. diff. = 30 F
LP pinch point temp. diff. = 30 F
LP pinch point at SH outlet= 80 F
Subcooling at HP economizer outlet = 20F
Subcooling at LP economizer outlet = 20F

Pressure Drop:

Main Steam line : 35 psi
HP superheater : 30 psi
HP economizer : 25 psi
LP economizer : 20 psi
LP superheater : 25 psi

5 GE- PG 7111EA gas turbines could be chosen because of availability of their most complete data base in our system and after some trial and error that it was found that these turbines matched the design requirements. There are several other alternatives such as PG7221FA, PG9171E, PG9331FA, or turbines by other manufacturers which should be included in a detailed feasibility study.

Also, the economic benefits of indirect heating systems, which employ heat exchangers in the subscribers premises (smaller pipe diameter in the distribution network) are considered favorable to low temperature large district heating networks.

The proposed combined cycle can be arranged in several ways such as 5 gas turbines, 5 heat recovery steam generators and one, two to five steam turbines.

In addition, this unit could be built in stages, therefore phasing in the investment required to construct the whole unit.

The gross capacity of the combined cycle unit is 644 MW. The heat rate for electricity is 1572 kcal(LHV)/kWhr (55%) which is very attractive. A proper optimized cycle may be expected to yield even lower heat rates.

A study should be undertaken to see the economic benefits of using electricity produced by this combined cycle unit to replace fossil fuels, such as imported coal and LPG that is currently used to provide heat for nearly 30% of the total facilities that are still not connected to the heating network. It has been reported that the fuel efficiency of these fossil fuels, especially coal, is as low as 30%.

8.6.3 Osh Power and Heating Station

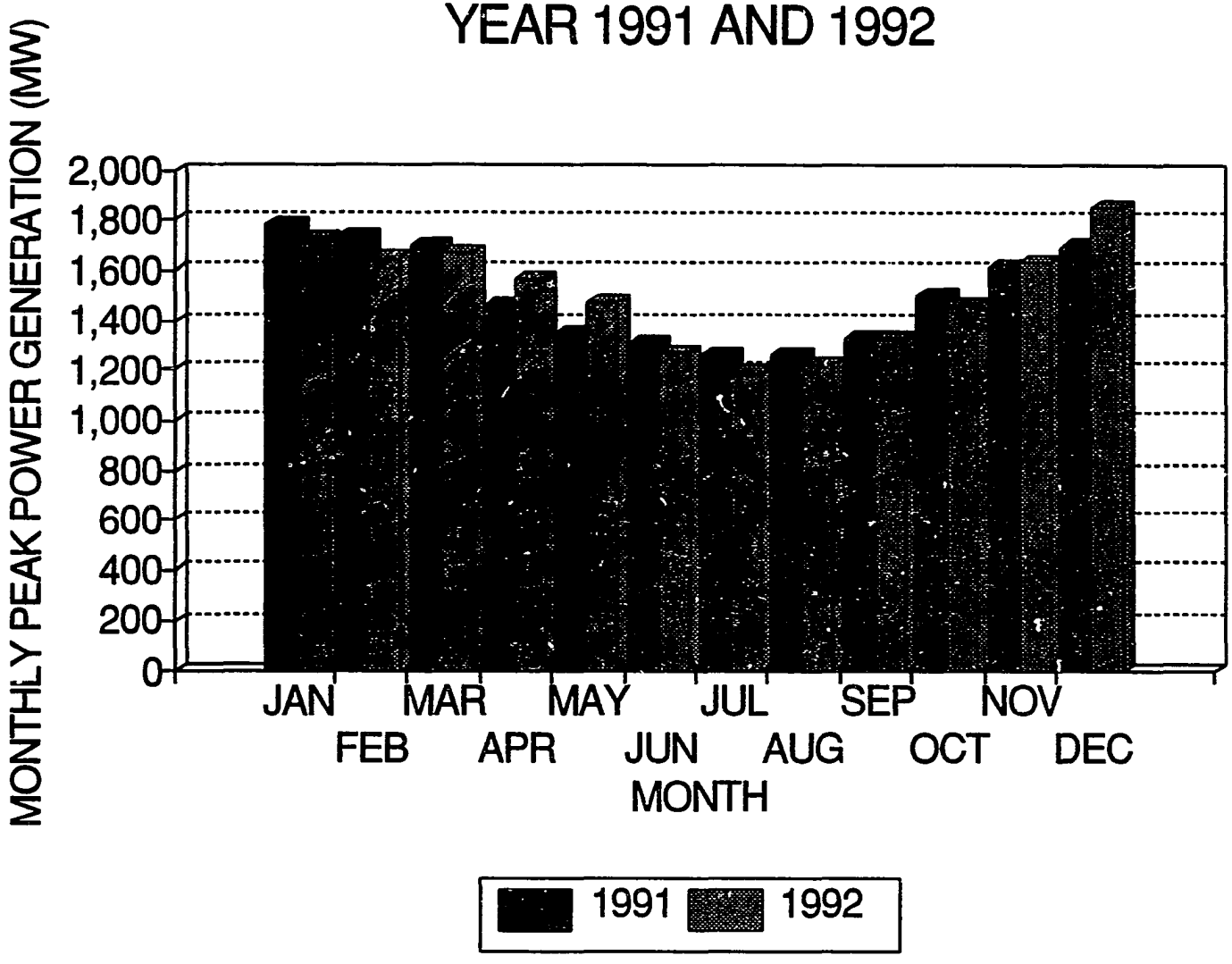
No major rehabilitation or repowering is planned or recommended for this station except for the addition of another 30 MW in the year 2001.

8.6.4 Mine-mouth Coal Plant

Karkachy coal fields in Naryn area has a billion tons of good quality coal which has the potential for surface mining. The coal has an approximate calorific value of 6750 kcal/kg. It is possible to develop a mine-mouth power plant in this coal field. The plant could be built in phases each phase consisting of 200 MW base load power plant using fluidized bed technology. A detailed feasibility study is required to quantify the cost of that option.

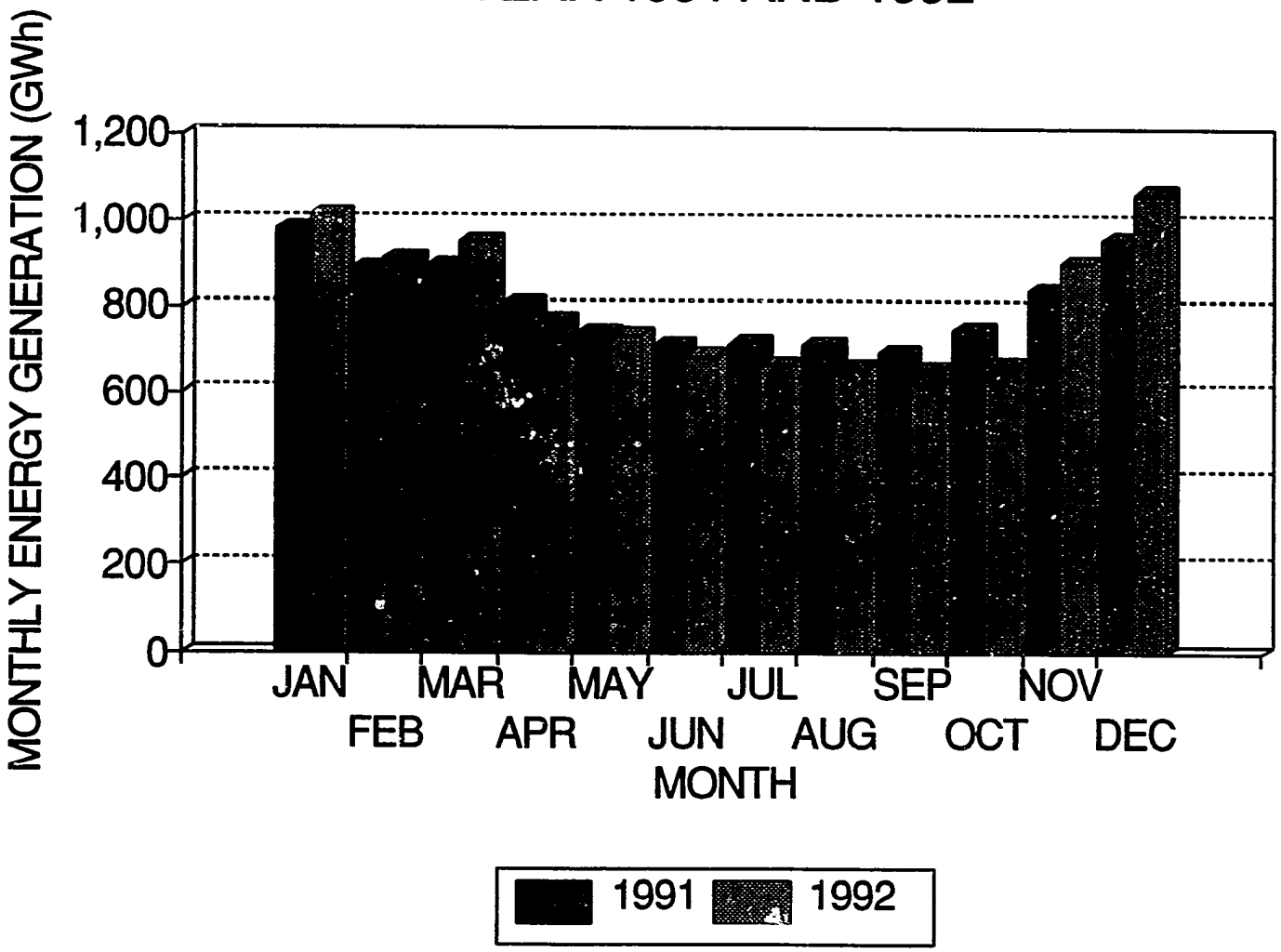
MONTHLY PEAK POWER GENERATION

YEAR 1991 AND 1992



MONTHLY ENERGY GENERATION

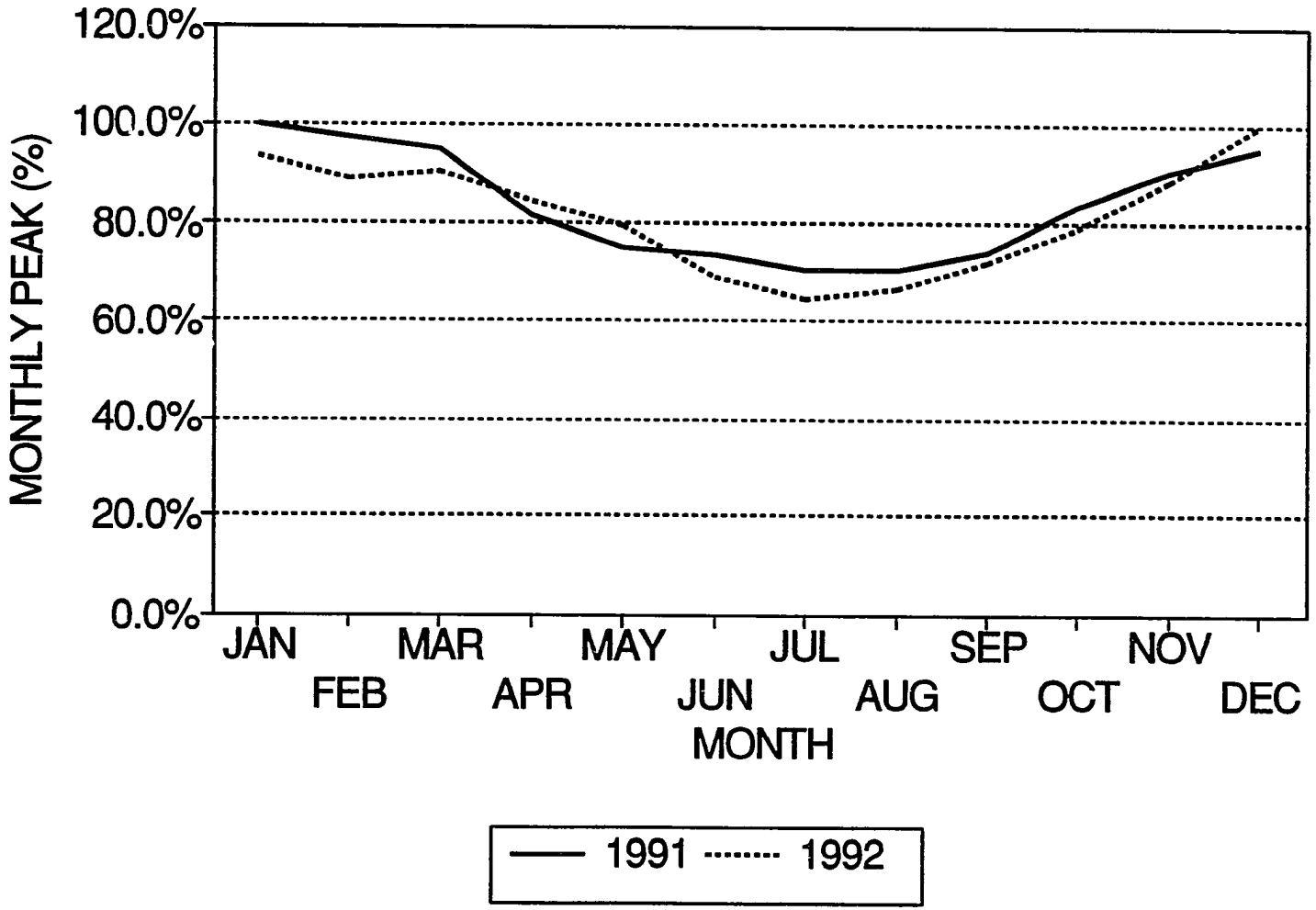
YEAR 1991 AND 1992



T 8-2

MONTHLY PEAK GENERATION

PERCENT OF ANNUAL PEAK



MONTHLY ENERGY GENERATION

PERCENT OF ANNUAL ENERGY

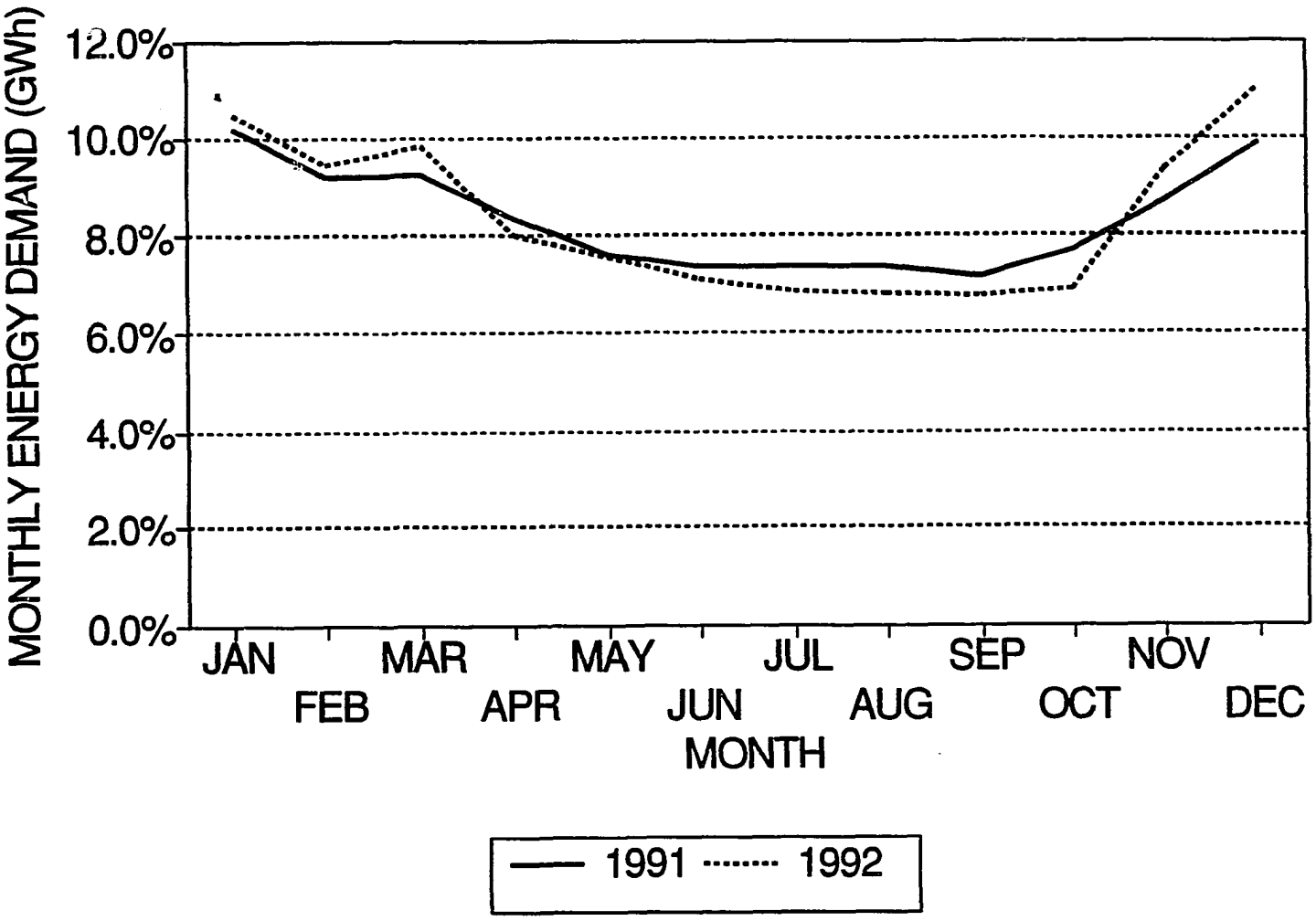


EXHIBIT 8-4

HYDROPOWER ENERGY GENERATION (MWh)
IRRIGATION SCENARIO

TOKTOGUL

MONTH	EXCEEDENCE LEVEL		
	10%	50%	90%
January	499,596	188,902	142,997
February	478,598	174,720	132,653
March	211,594	193,738	148,874
April	203,904	185,832	142,200
May	209,957	190,687	147,163
June	857,376	394,056	277,128
July	887,071	671,088	470,952
August	887,220	773,239	555,098
September	487,440	401,904	304,416
October	296,484	182,652	127,150
November	290,448	179,136	124,200
December	598,622	185,702	134,441
Annual	5,433,931	3,794,278	2,731,255

KURPSAI

MONTH	EXCEEDENCE LEVEL		
	10%	50%	90%
January	118,296	115,915	114,130
February	152,208	145,757	142,531
March	221,117	215,760	197,830
April	131,256	120,888	113,904
May	313,001	155,347	134,441
June	576,000	305,784	163,080
July	595,200	468,050	333,758
August	595,200	441,787	332,568
September	234,216	132,408	117,432
October	164,350	121,340	118,296
November	131,256	115,632	113,328
December	118,891	116,510	115,320
Annual	3,135,509	2,591,887	2,172,514

TASHKUMYR

MONTH	EXCEEDENCE LEVEL		
	10%	50%	90%
January	75,962	73,656	71,722
February	93,744	90,586	89,040
March	136,152	133,846	129,233
April	107,640	98,352	86,616
May	214,644	126,182	109,070
June	324,000	194,544	131,184
July	334,800	290,755	221,712
August	334,800	270,667	205,790
September	148,248	88,632	75,960
October	132,060	83,254	76,260
November	84,600	74,304	73,080
December	76,855	74,326	72,540
Annual	1,947,991	1,633,490	1,464,065

SHAMALDYSAI

MONTH	EXCEEDENCE LEVEL		
	10%	50%	90%
January	42,185	40,994	
February	51,274	49,459	
March	73,805	72,614	
April	58,680	53,712	
May	121,570	68,597	
June	172,800	104,184	71,136
July	178,560	153,859	118,370
August	178,560	141,732	109,814
September	80,064	48,600	42,120
October	55,577	43,970	41,813
November	46,512	41,256	40,680
December	43,152	41,515	40,474
Annual	1,037,549	885,014	796,939

UCH-KURGAN

MONTH	EXCEEDENCE LEVEL		
	10%	50%	90%
January	45,012	43,747	42,631
February	52,282	50,534	49,325
March	73,954	72,689	70,234
April	61,848	56,736	50,184
May	115,990	70,085	60,710
June	129,600	101,160	67,824
July	133,920	130,126	111,823
August	133,920	131,390	104,904
September	80,640	48,312	41,184
October	59,446	45,830	43,822
November	47,952	42,192	41,400
December	44,789	43,301	42,334
Annual	950,957	822,403	768,362

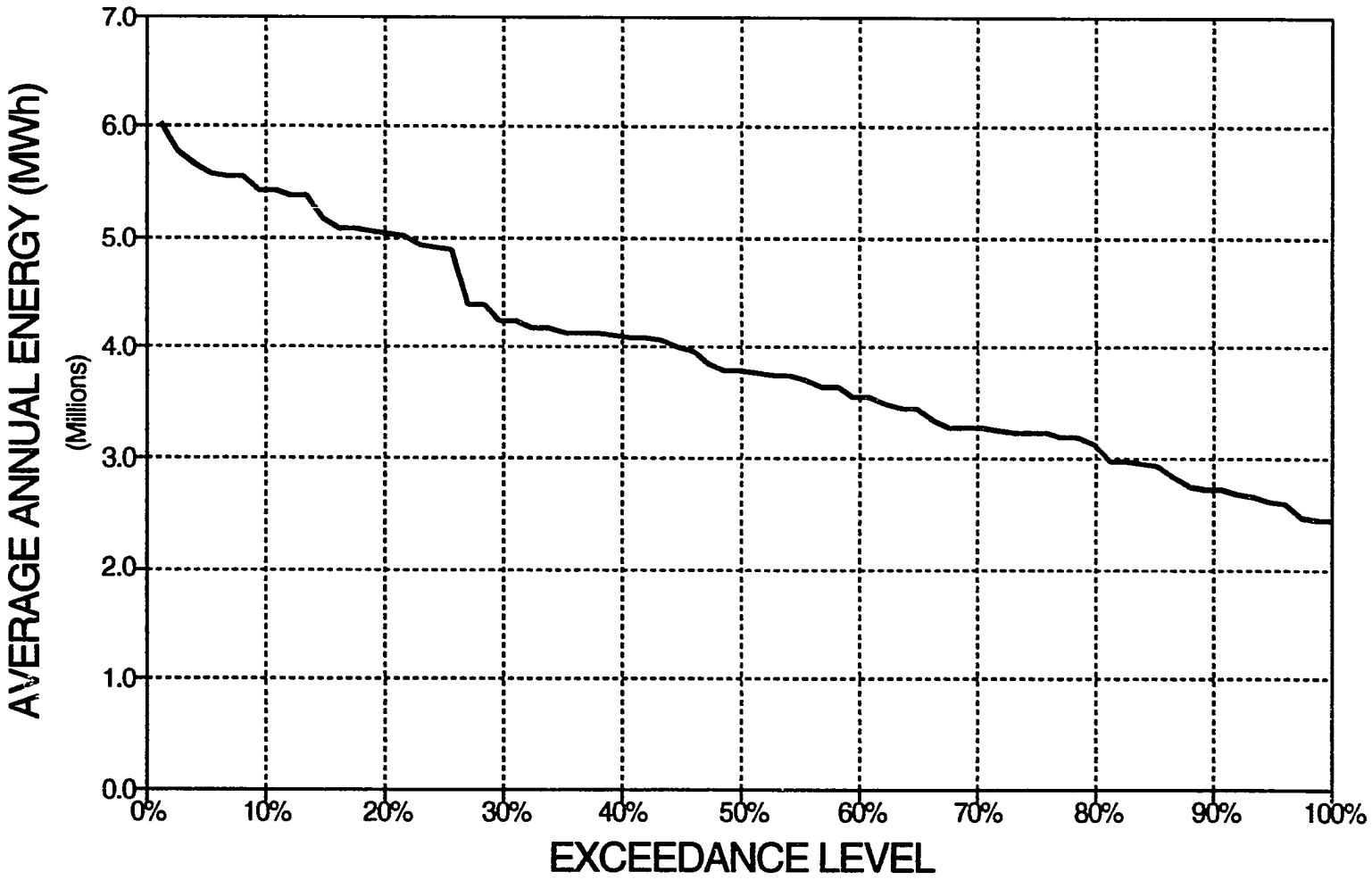
KAMBARATA #2

MONTH	EXCEEDENCE LEVEL		
	10%	50%	90%
January	133,846	131,837	128,489
February	135,341	127,075	120,019
March	48,881	46,202	42,780
April	0	0	0
May	0	0	0
June	251,352	106,128	0
July	260,028	199,838	123,727
August	237,782	161,002	122,611
September	129,384	84,168	67,176
October	73,730	56,693	46,351
November	73,368	73,296	73,152
December	160,704	158,100	156,017
Annual	1,418,628	1,130,062	921,907

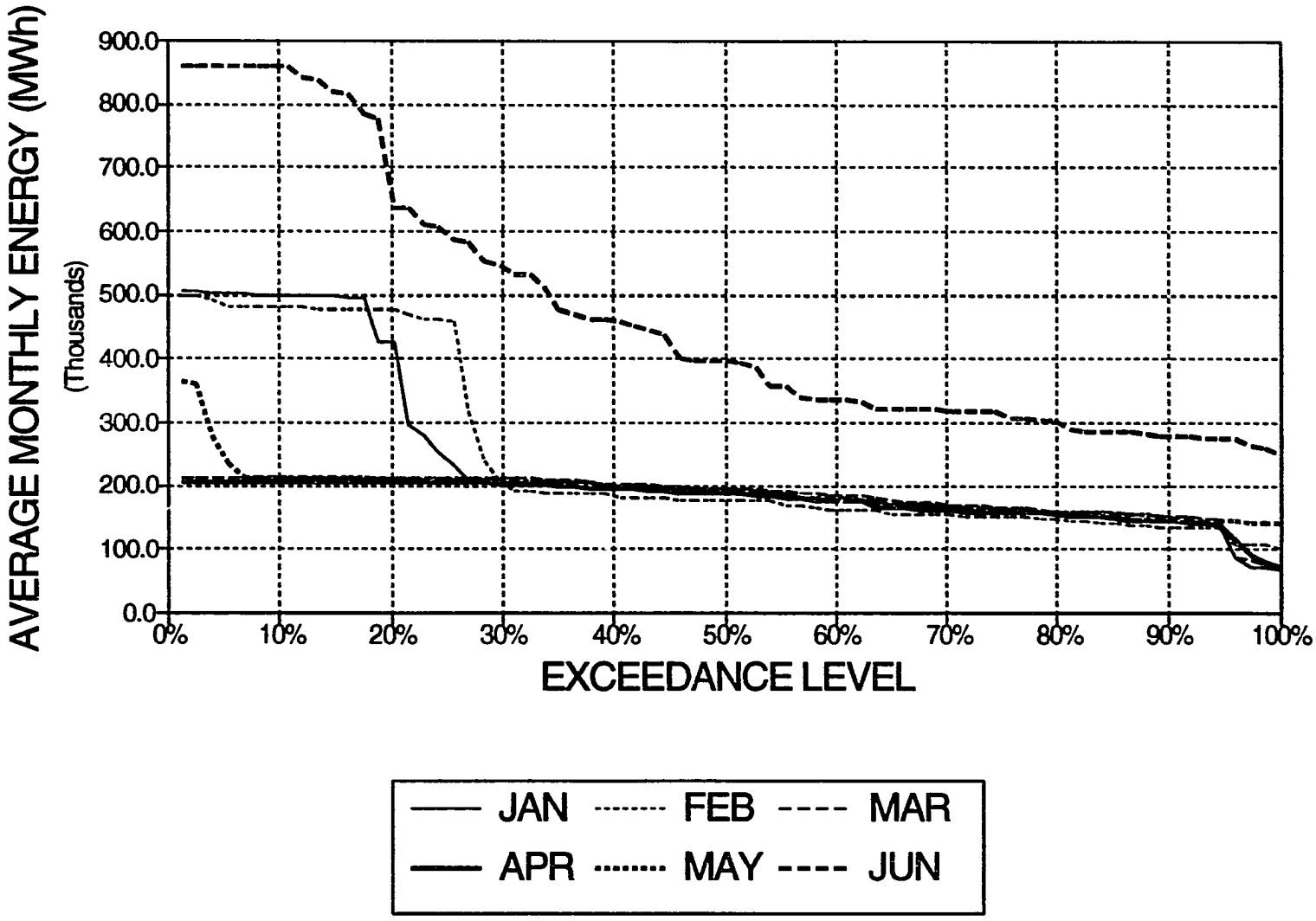
KAMBARATA #1

MONTH	EXCEEDENCE LEVEL		
	10%	50%	90%
January	554,875	550,486	538,582
February	482,160	472,886	467,981
March	154,975	152,446	147,758
April	0	0	0
May	0	0	0
June	1,351,656	487,440	0
July	1,396,786	966,456	585,156
August	1,152,754	773,834	581,659
September	599,472	394,056	311,688
October	339,115	255,638	206,014
November	336,456	336,312	327,240
December	734,179	729,864	723,242
Annual	6,738,001	4,944,137	4,105,183

TOKTOGUL #1
ANNUAL ENERGY GENERATION



TOKTOGUL #1
MONTHLY ENERGY GENERATION



TOKTOGUL #1
MONTHLY ENERGY GENERATION

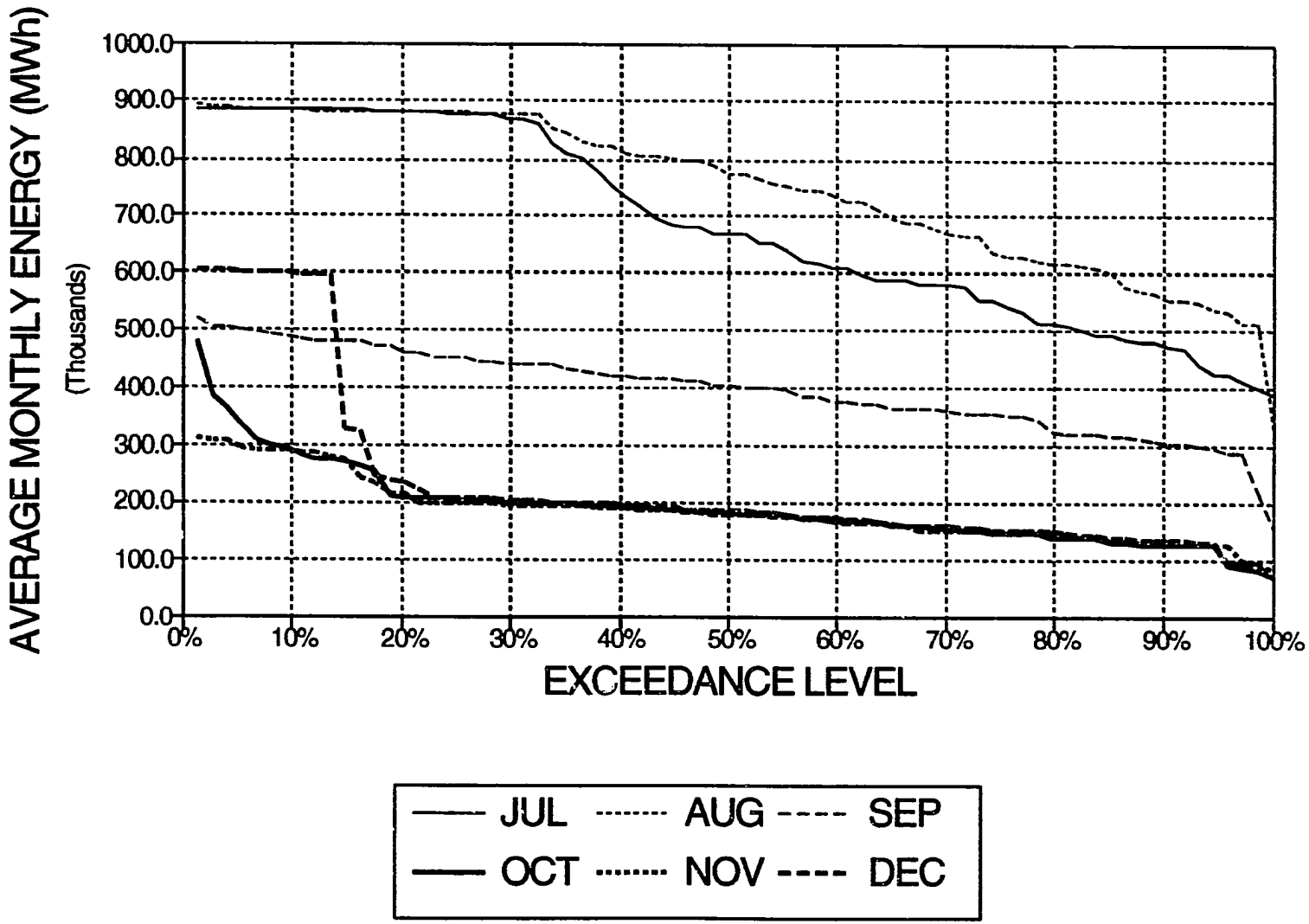


EXHIBIT 8-6

KURPSAI
ANNUAL ENERGY GENERATION

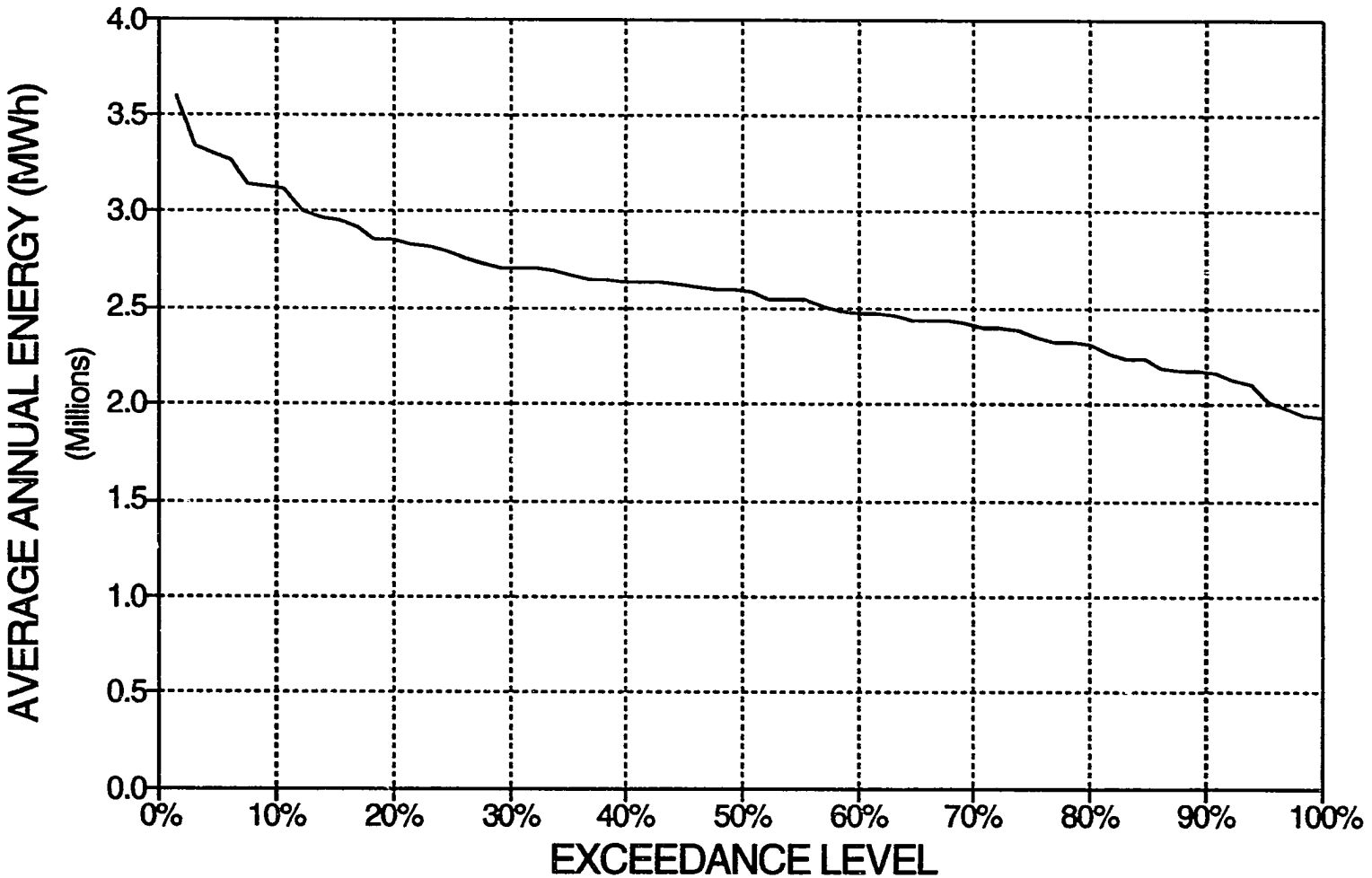


EXHIBIT 8-7

KURPSAI
MONTHLY ENERGY GENERATION

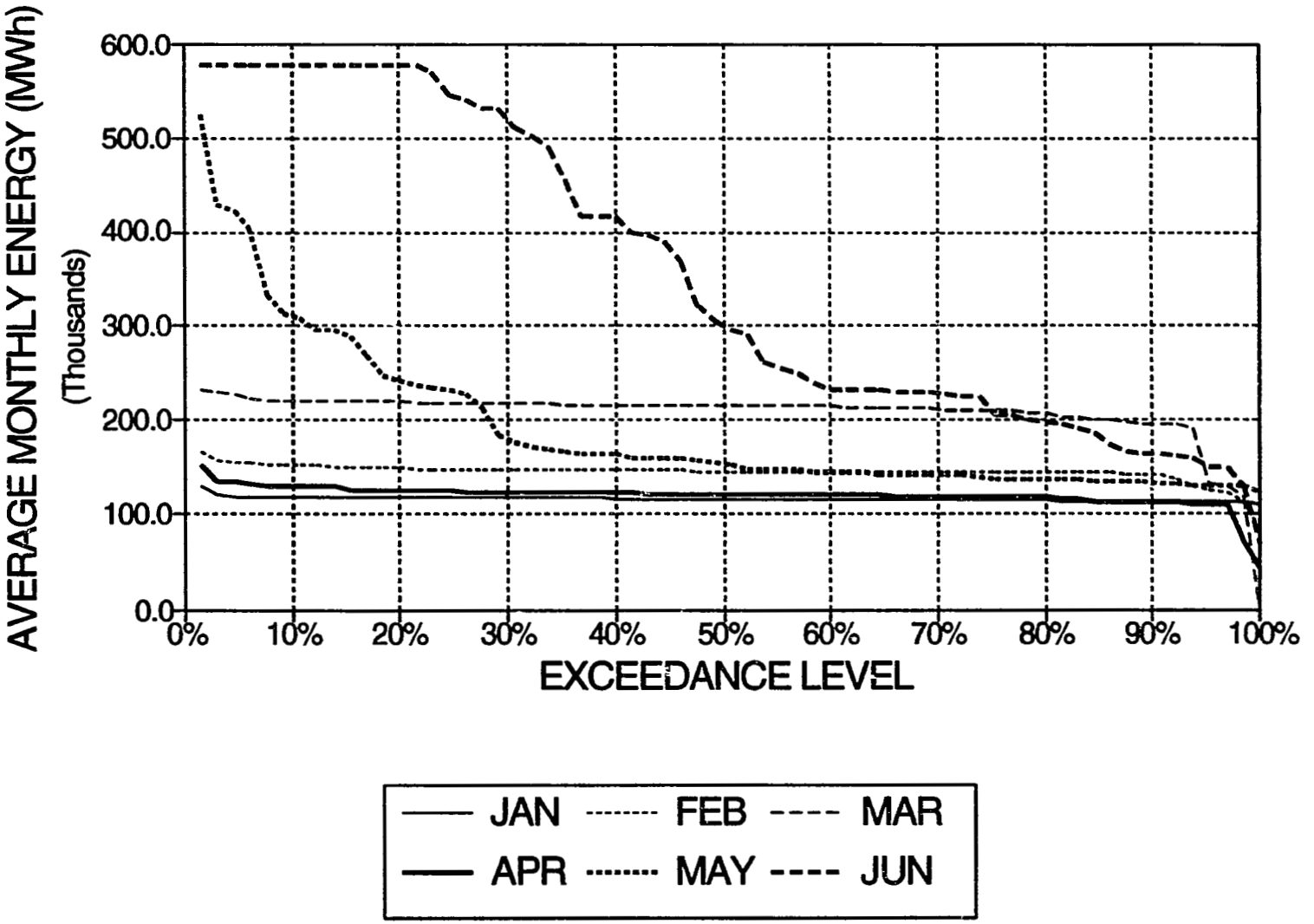
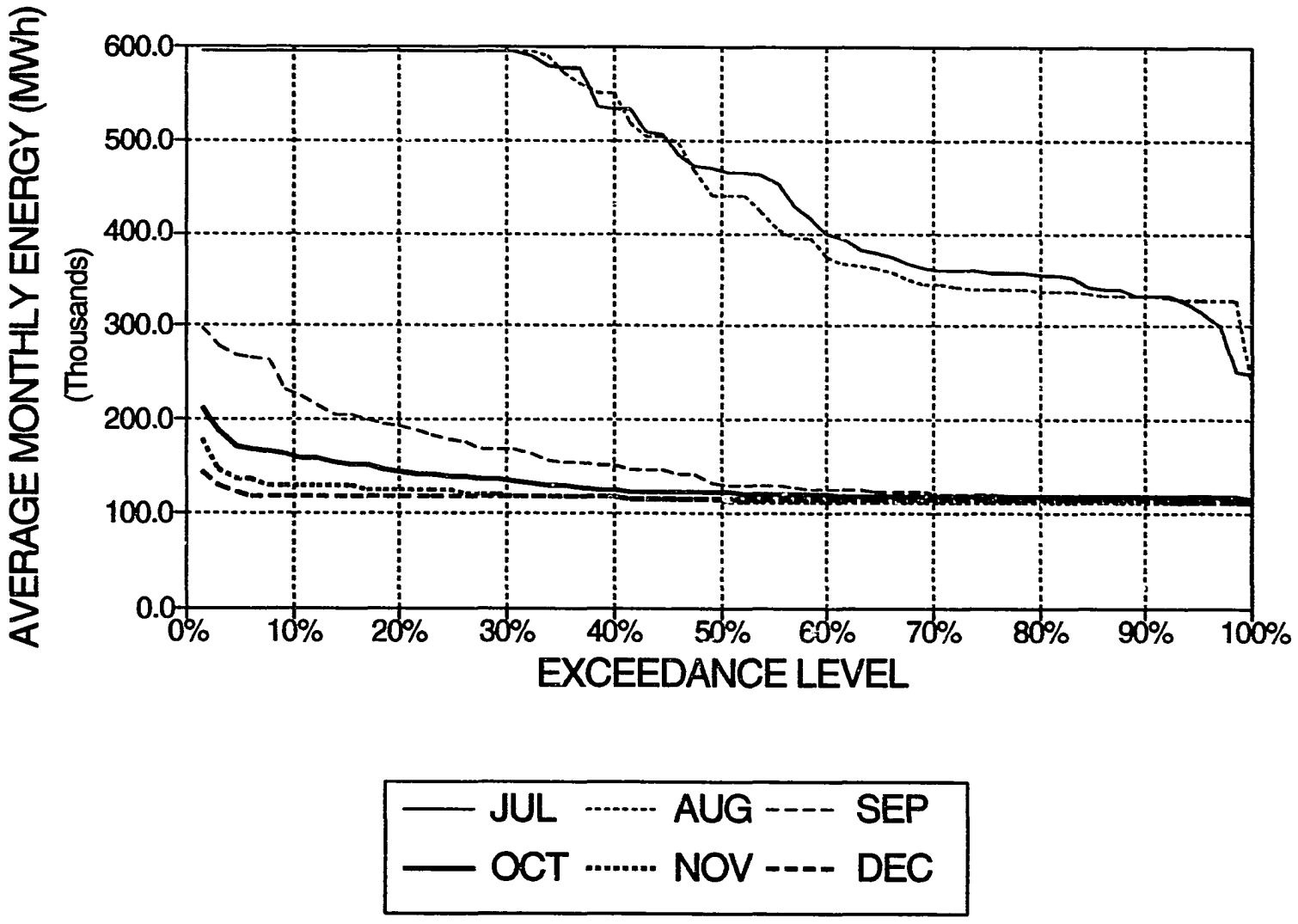


EXHIBIT 8-7

KURPSAI
MONTHLY ENERGY GENERATION



TASHKUMYR
ANNUAL ENERGY GENERATION

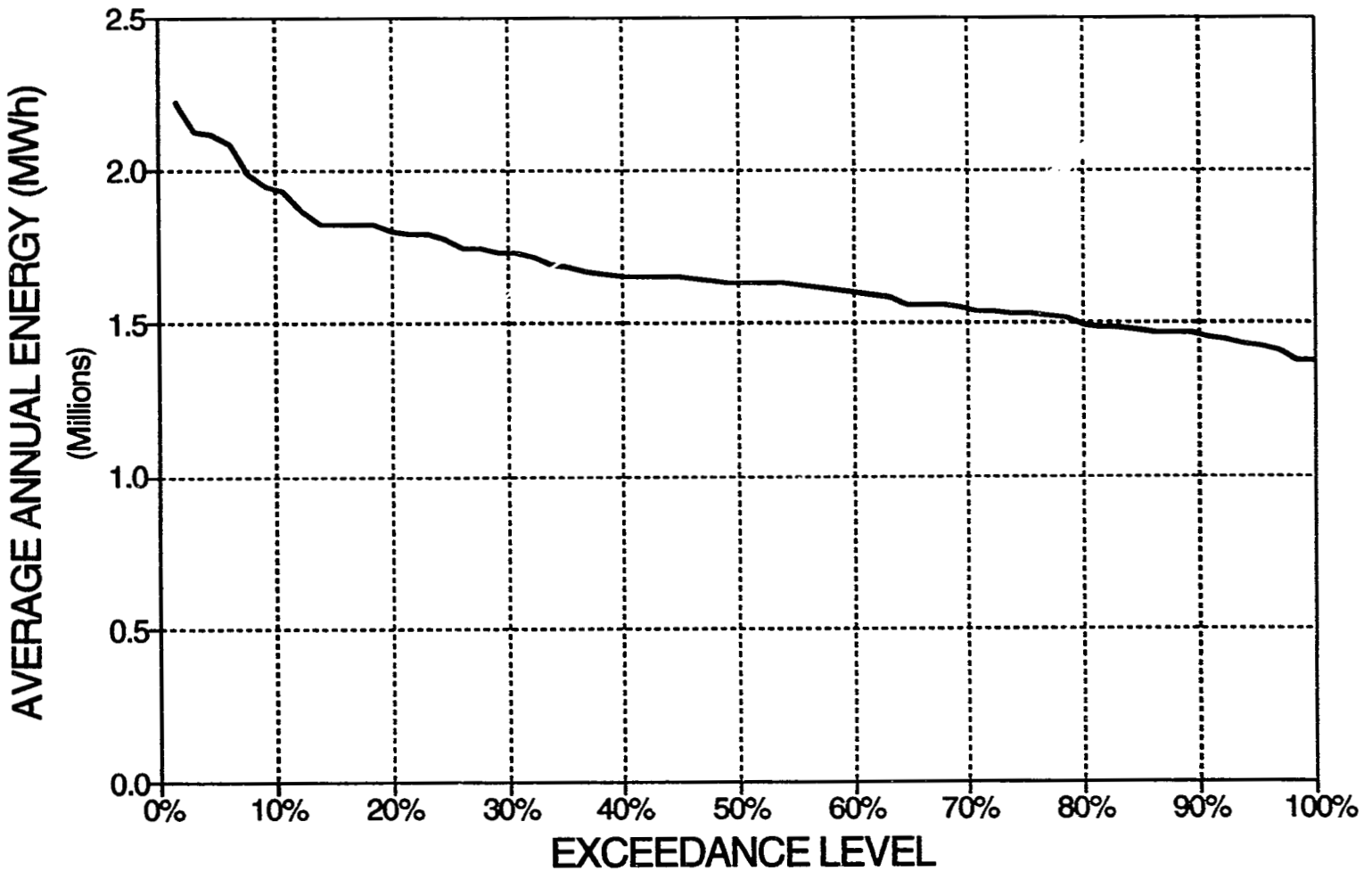


EXHIBIT 8-8

TASHKUMYR
MONTHLY ENERGY GENERATION

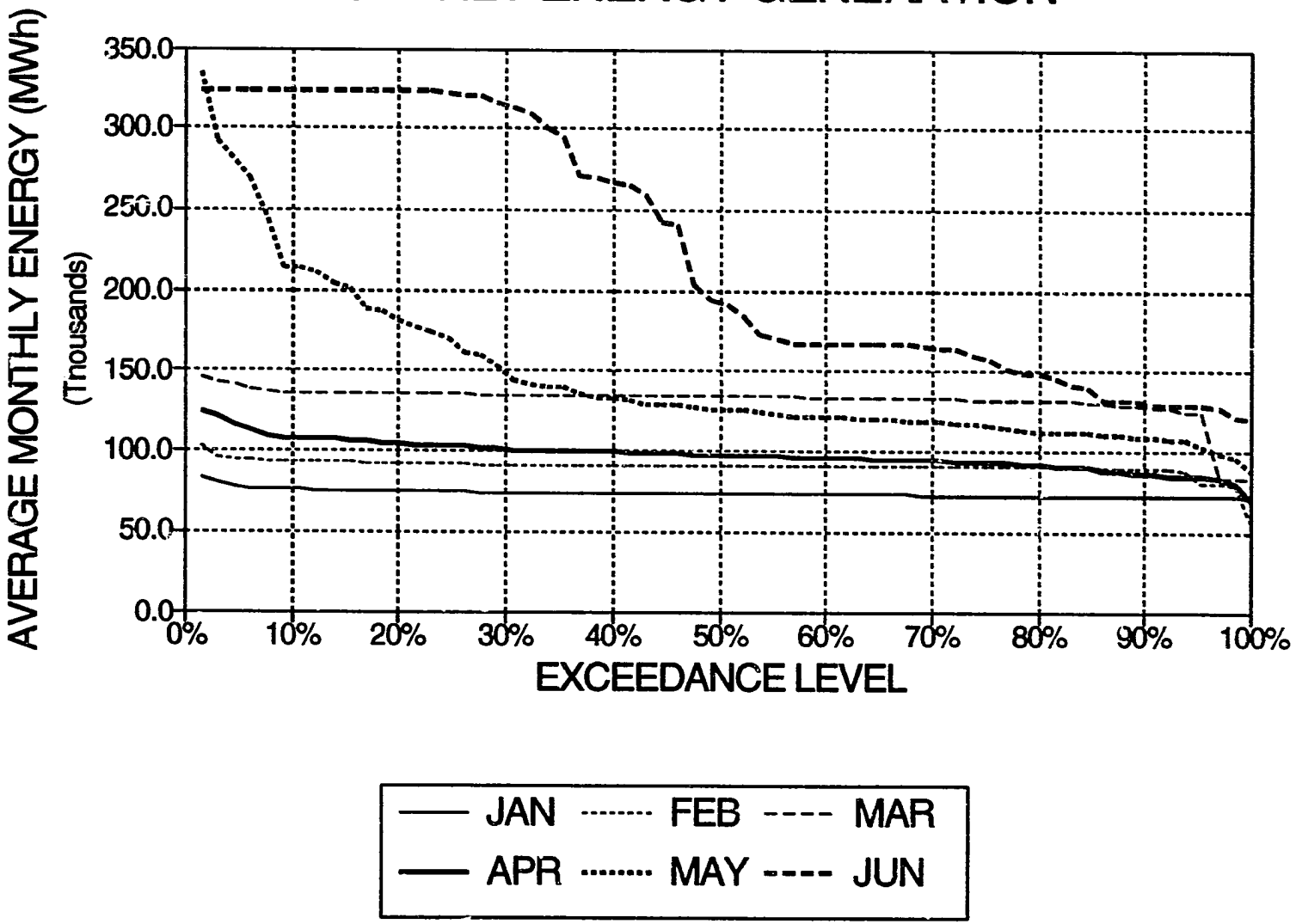


EXHIBIT 8-8

TASHKUMYR
MONTHLY ENERGY GENERATION

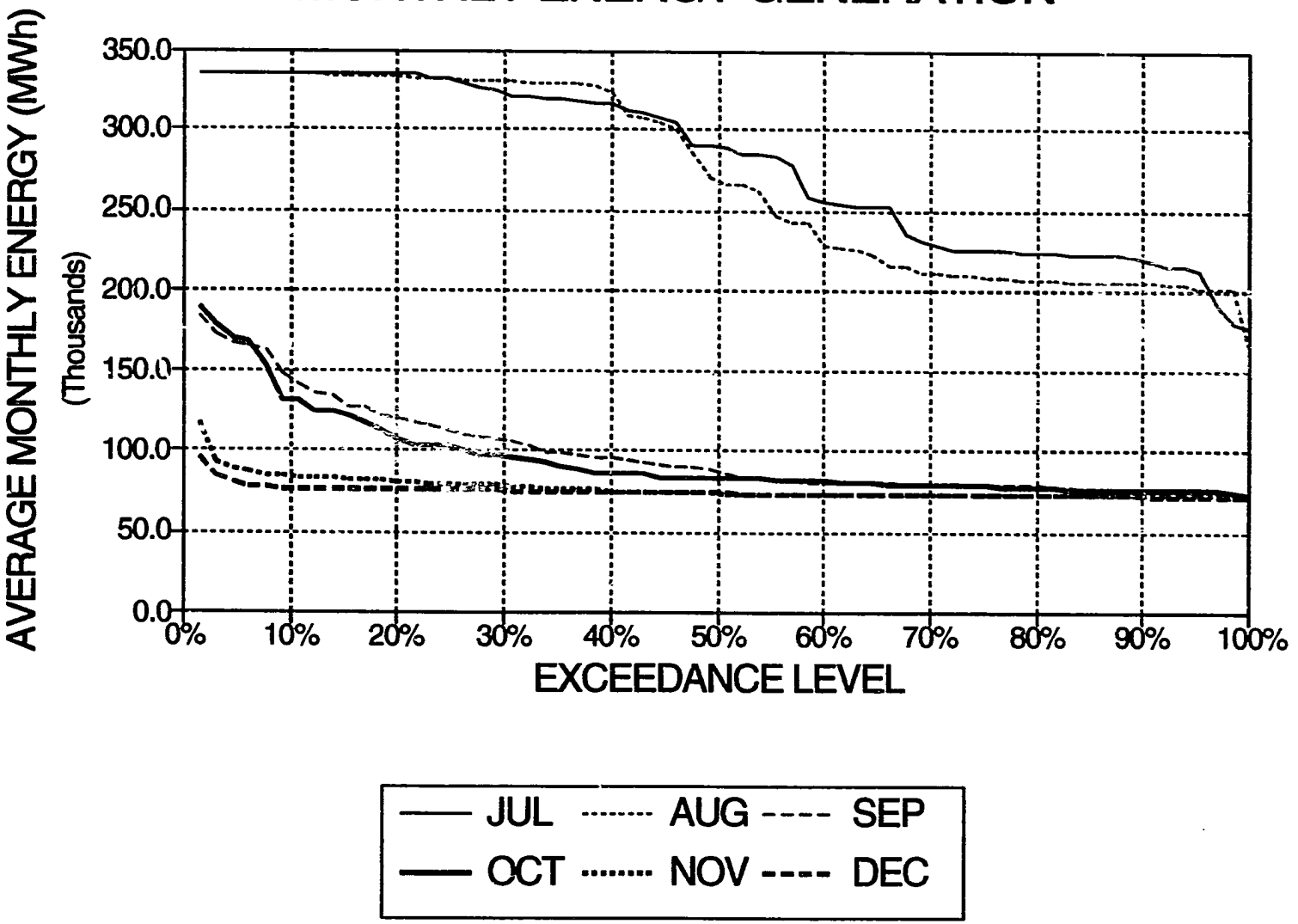


EXHIBIT 8-8

SHAMALDYSAI
ANNUAL ENERGY GENERATION

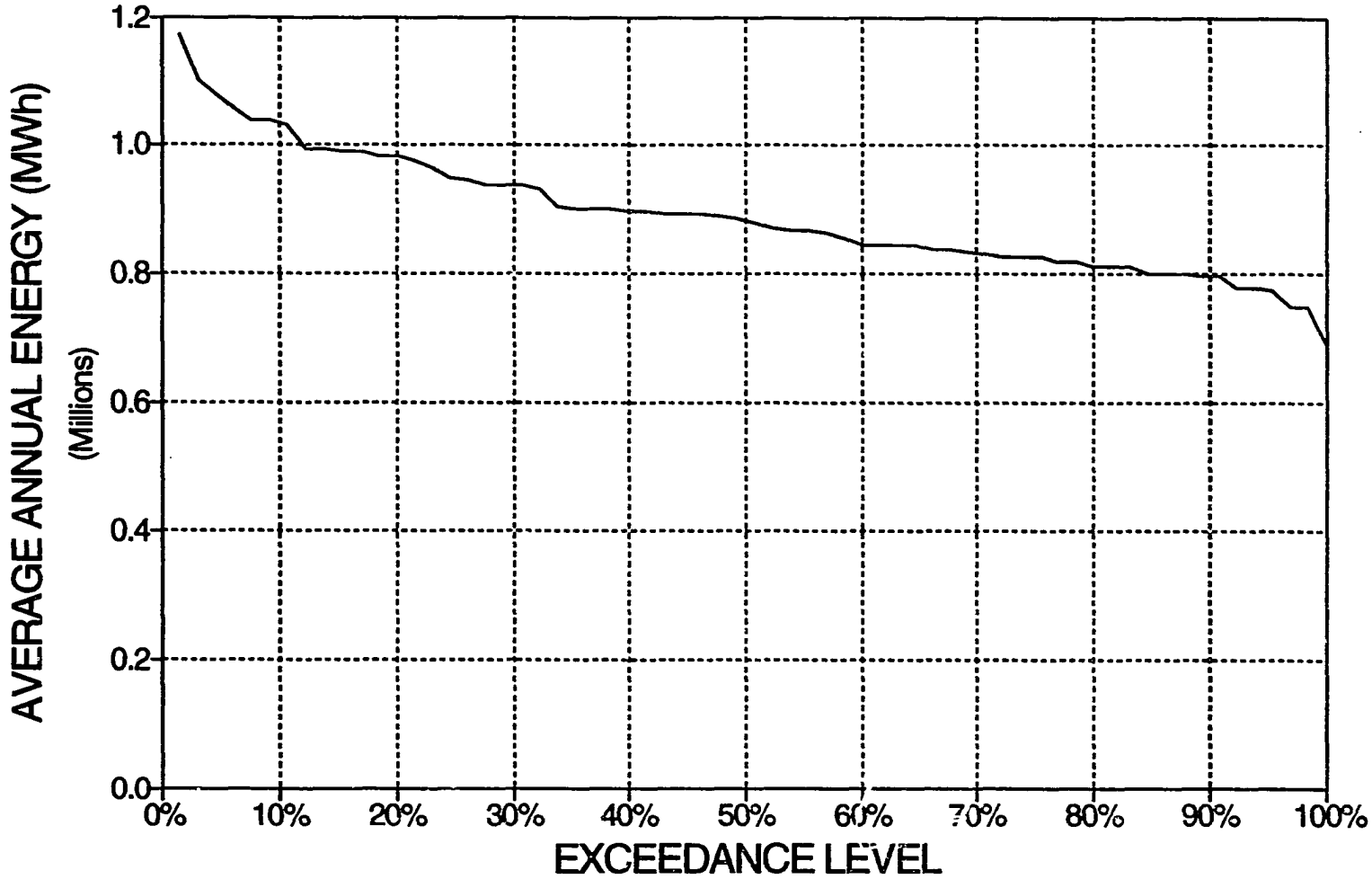


EXHIBIT 8-9

SHAMALDYSAI
MONTHLY ENERGY GENERATION

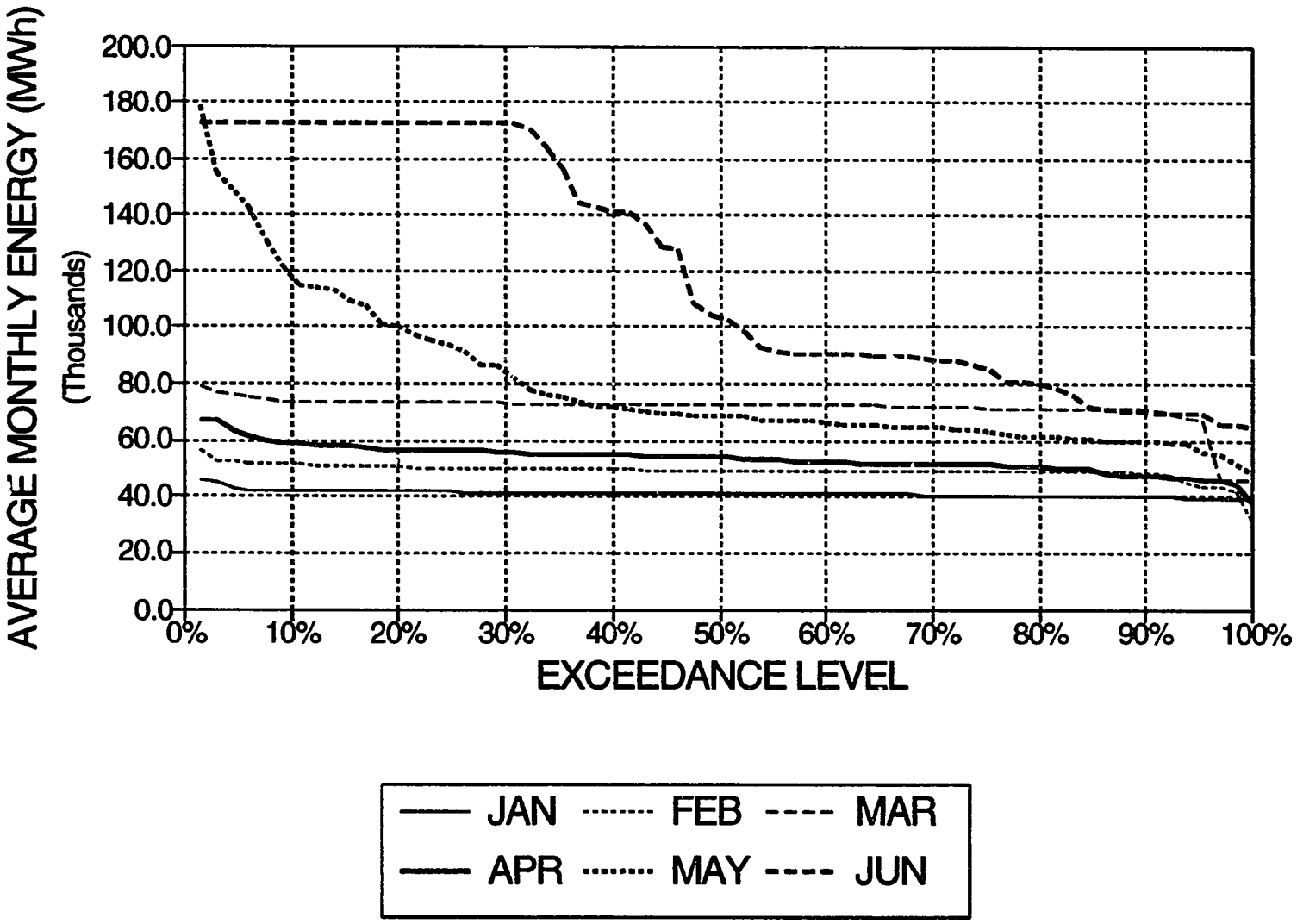


EXHIBIT 8-9

SHAMALDYSAI
MONTHLY ENERGY GENERATION

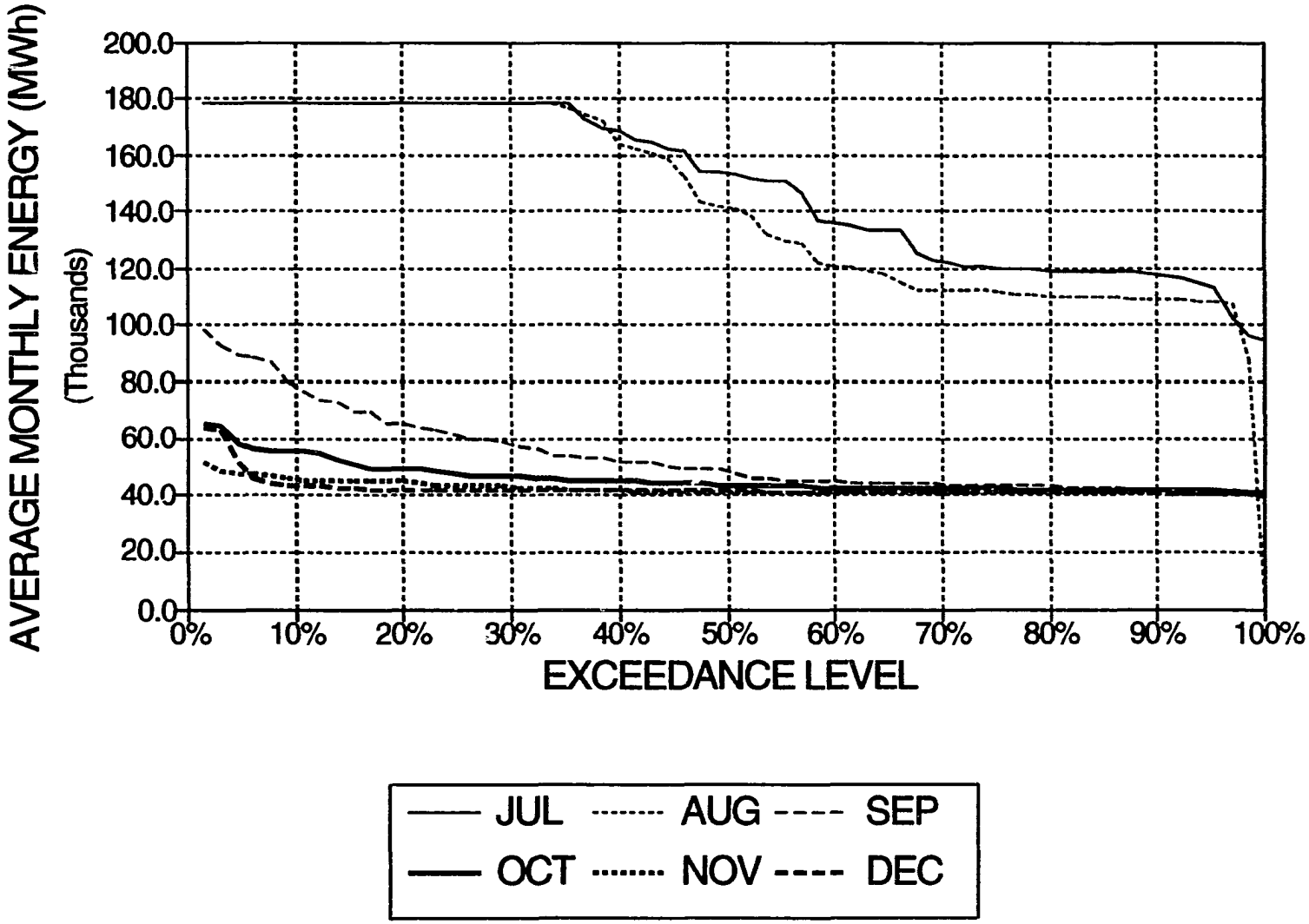


EXHIBIT 8-9

UCH-KURGAN
ANNUAL ENERGY GENERATION

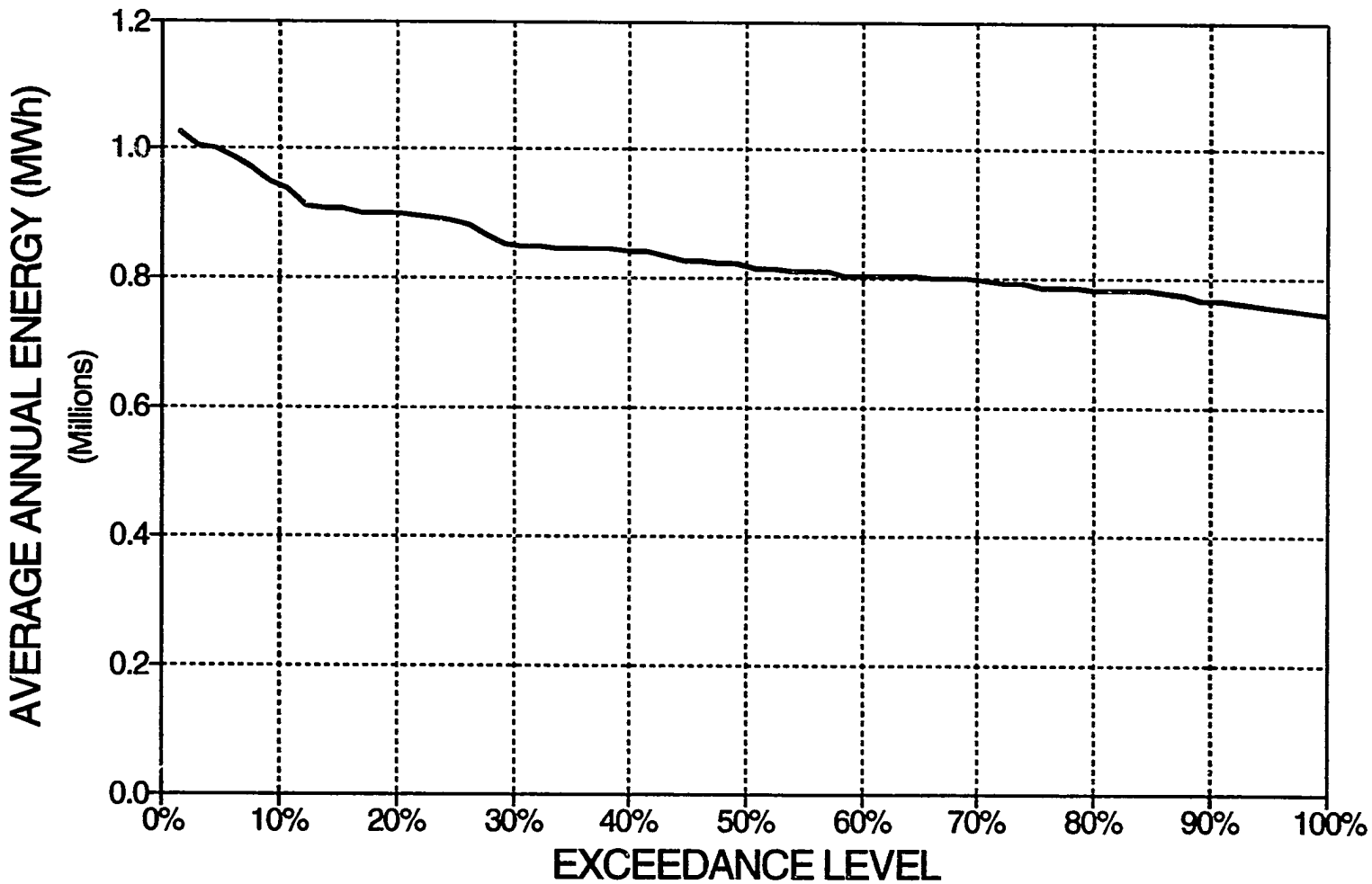


EXHIBIT 8-10

UCH-KURGAN
MONTHLY ENERGY GENERATION

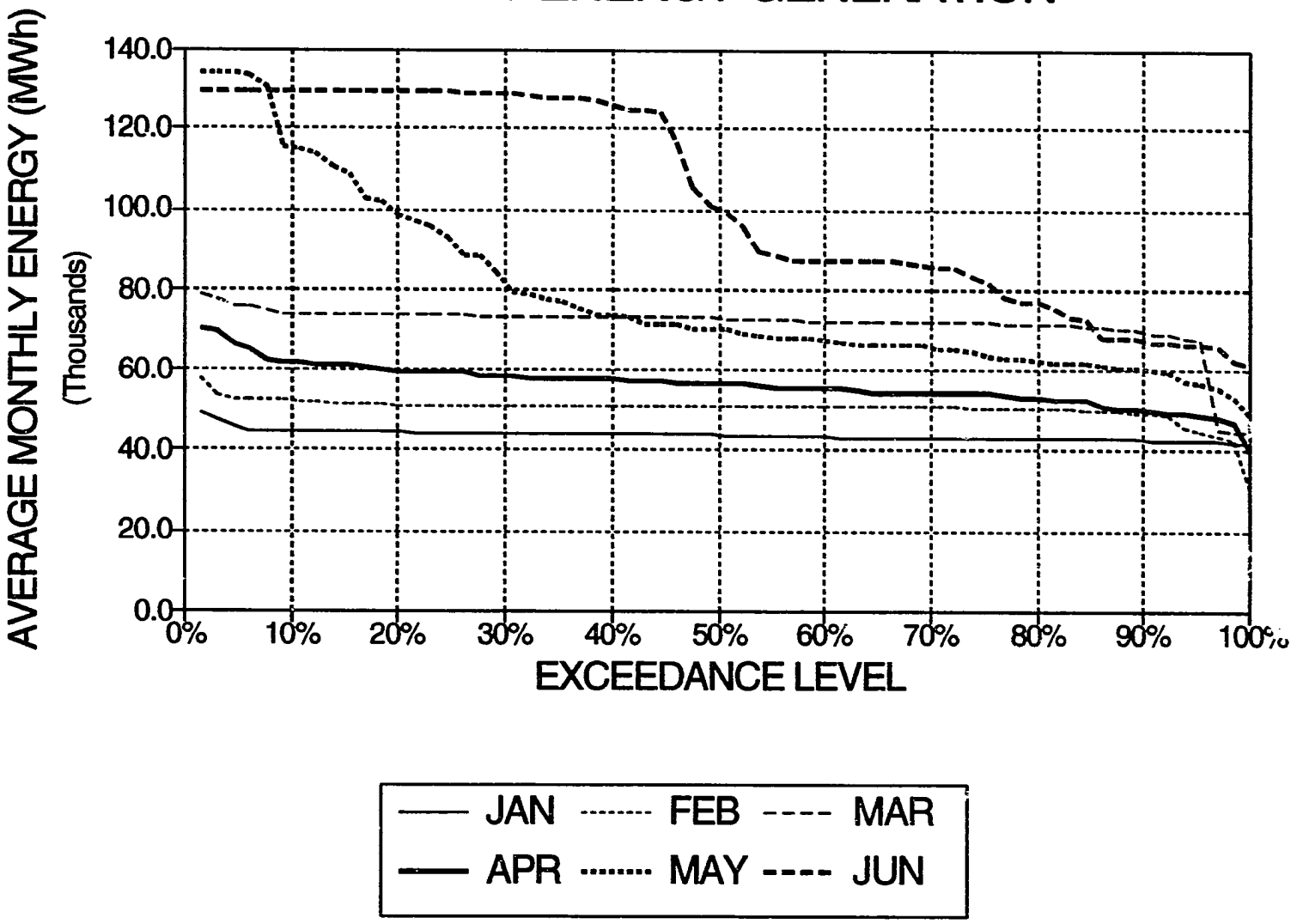


EXHIBIT 8-10

UCH-KURGAN
MONTHLY ENERGY GENERATION

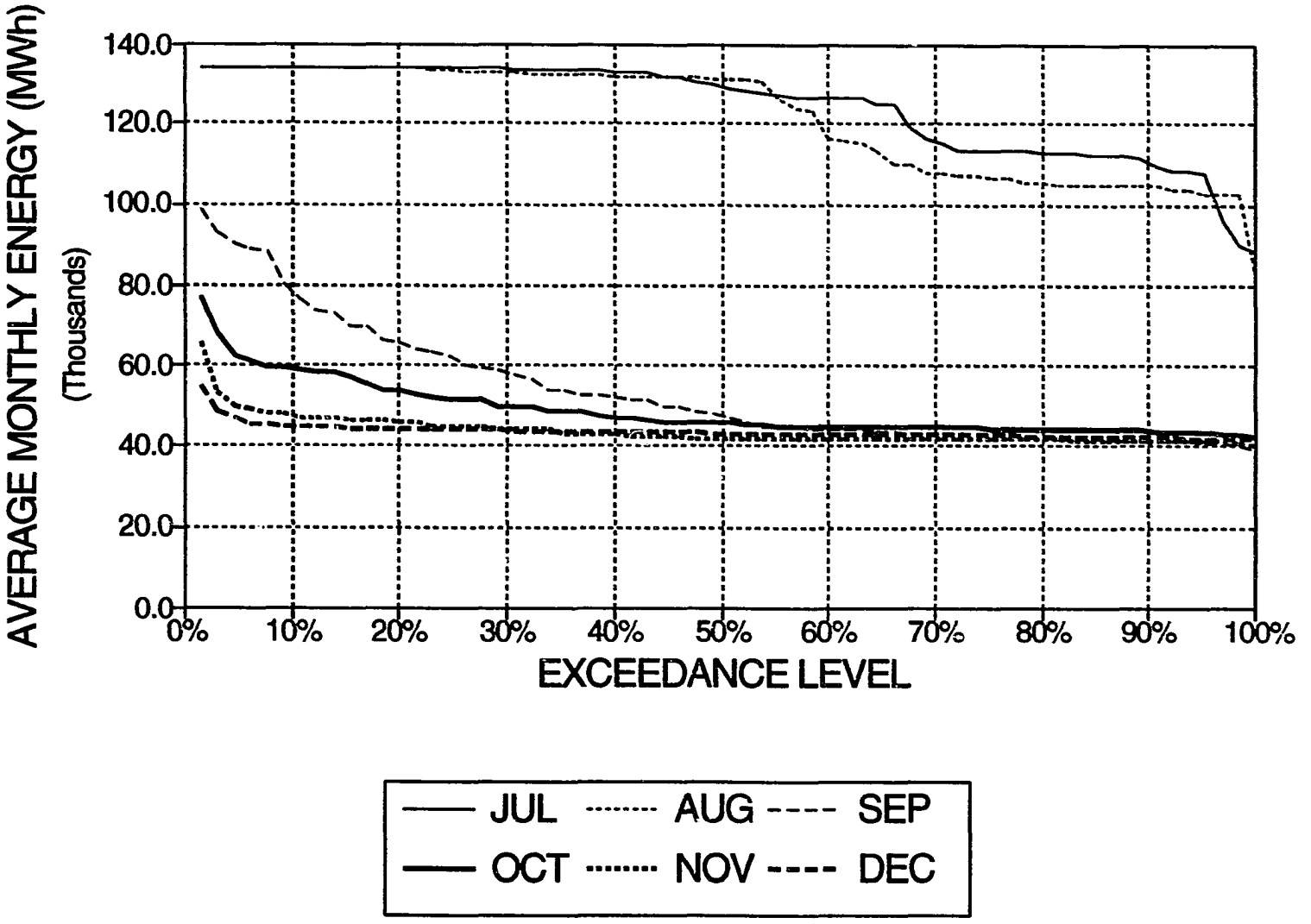


EXHIBIT 8-10

KAMBARATA #2
ANNUAL ENERGY GENERATION

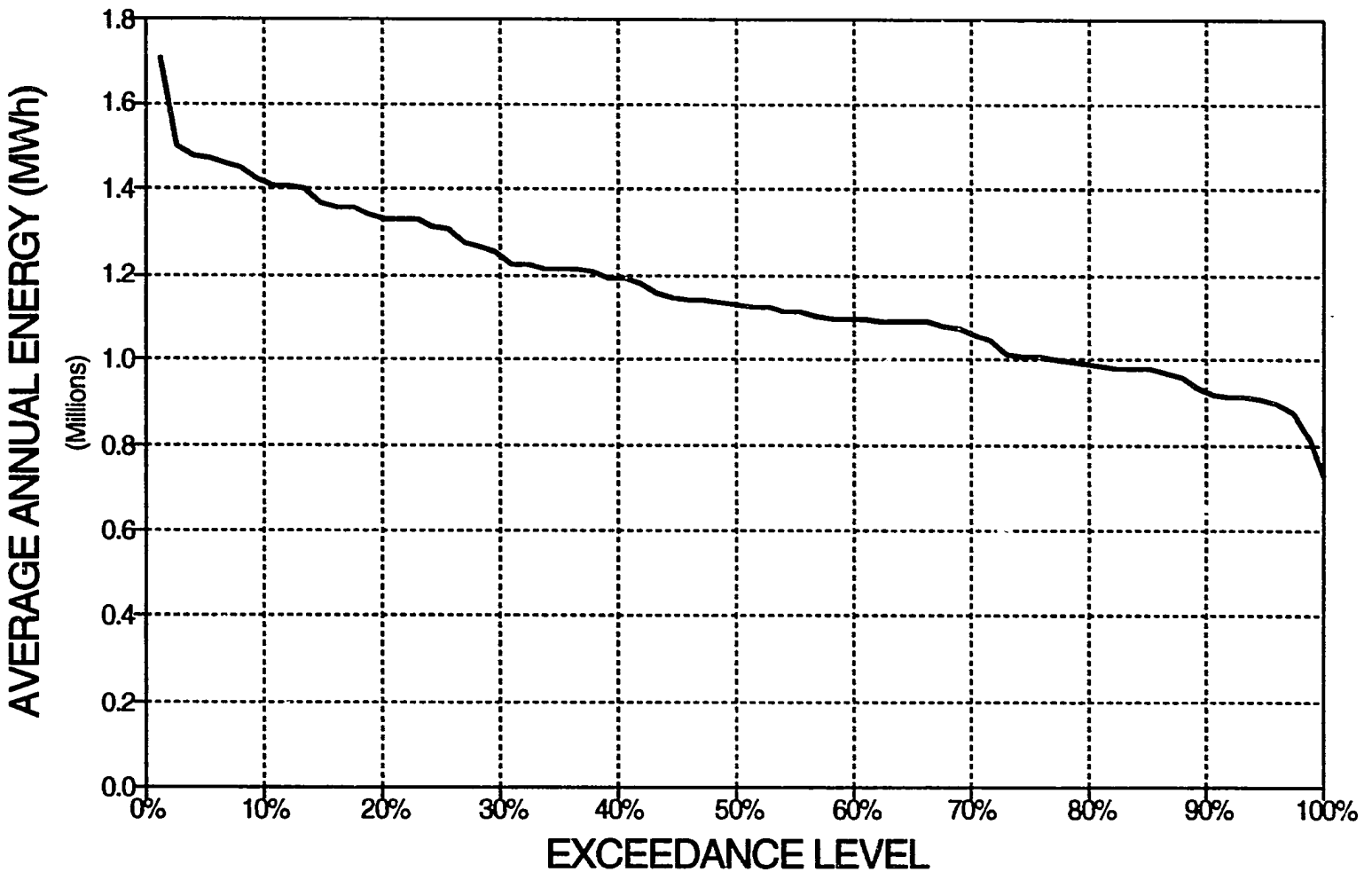


EXHIBIT 8-11

KAMBARATA #2
MONTHLY ENERGY GENERATION

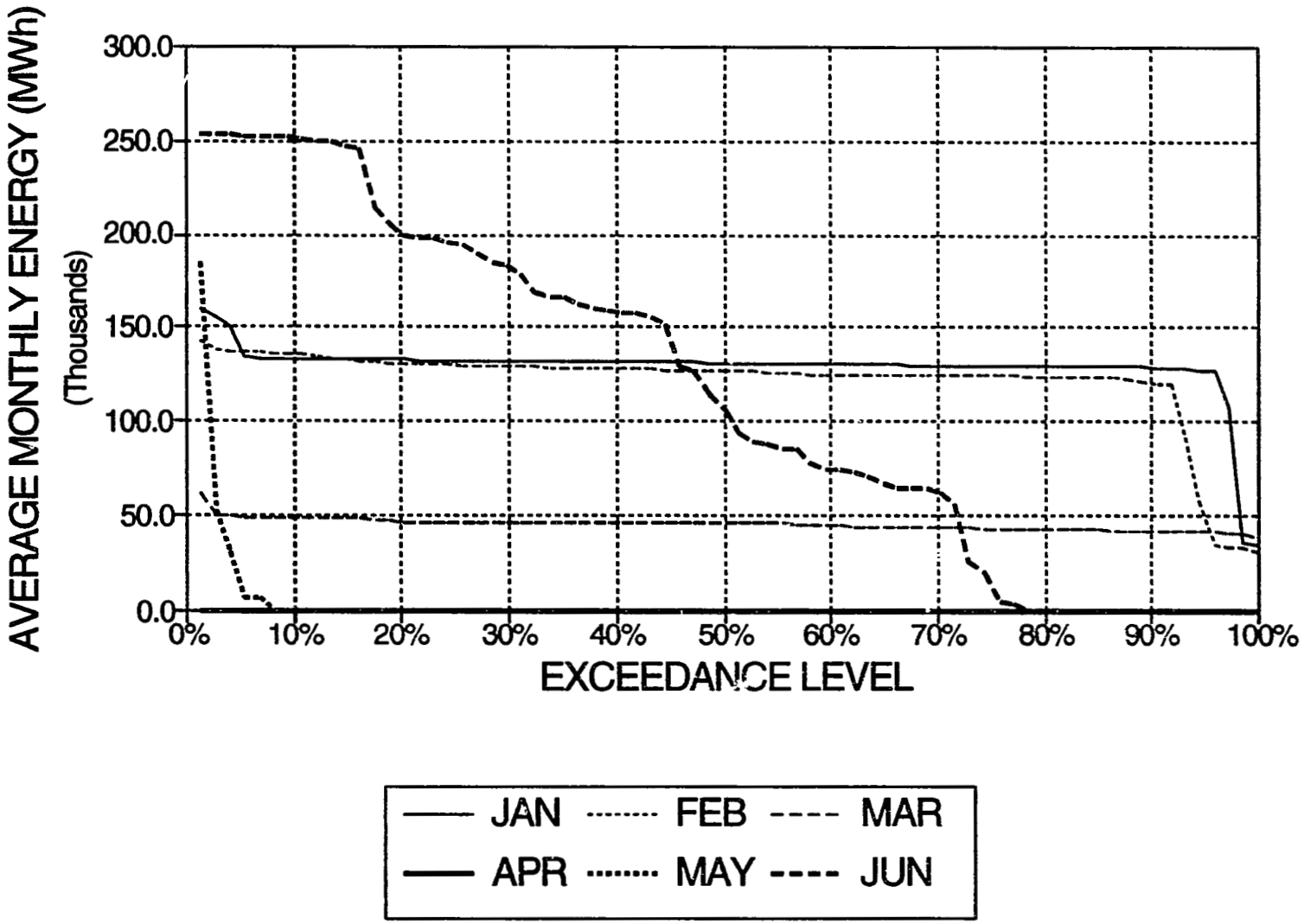


EXHIBIT 8-11

KAMBARATA #2
MONTHLY ENERGY GENERATION

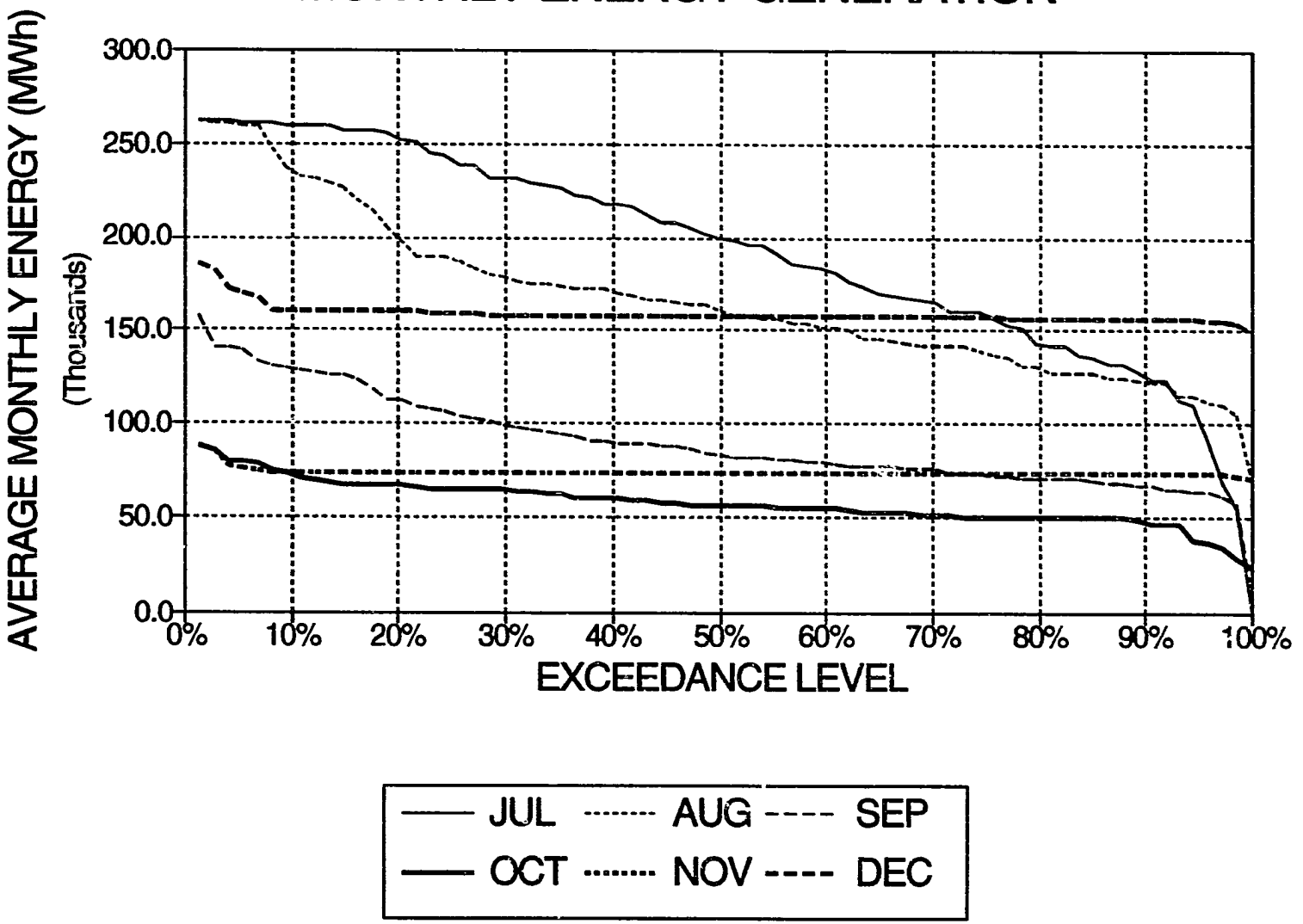


EXHIBIT 8-11

KAMBARATA #1
ANNUAL ENERGY GENERATION

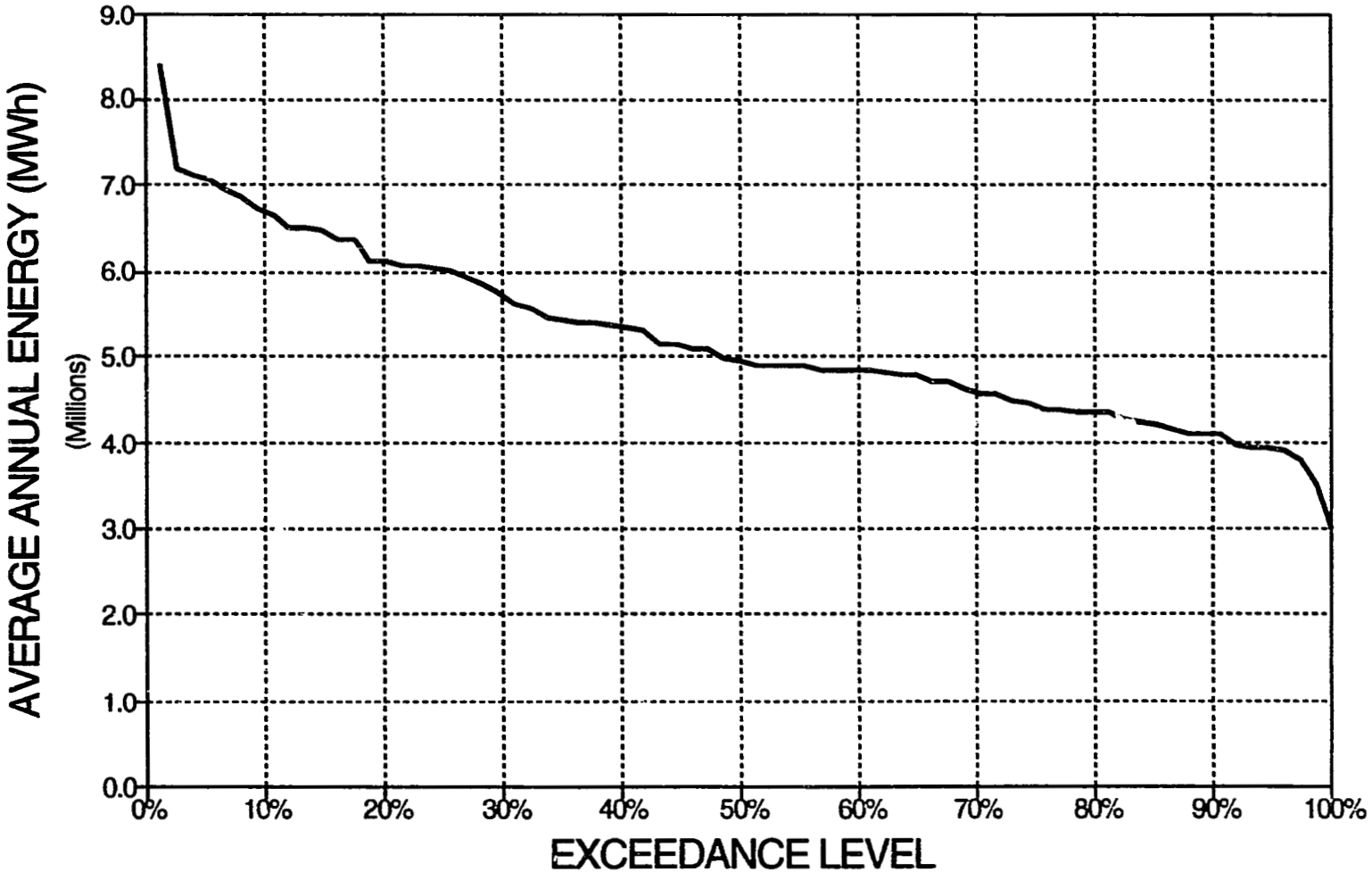


EXHIBIT 8-12

KAMBARATA #1
MONTHLY ENERGY GENERATION

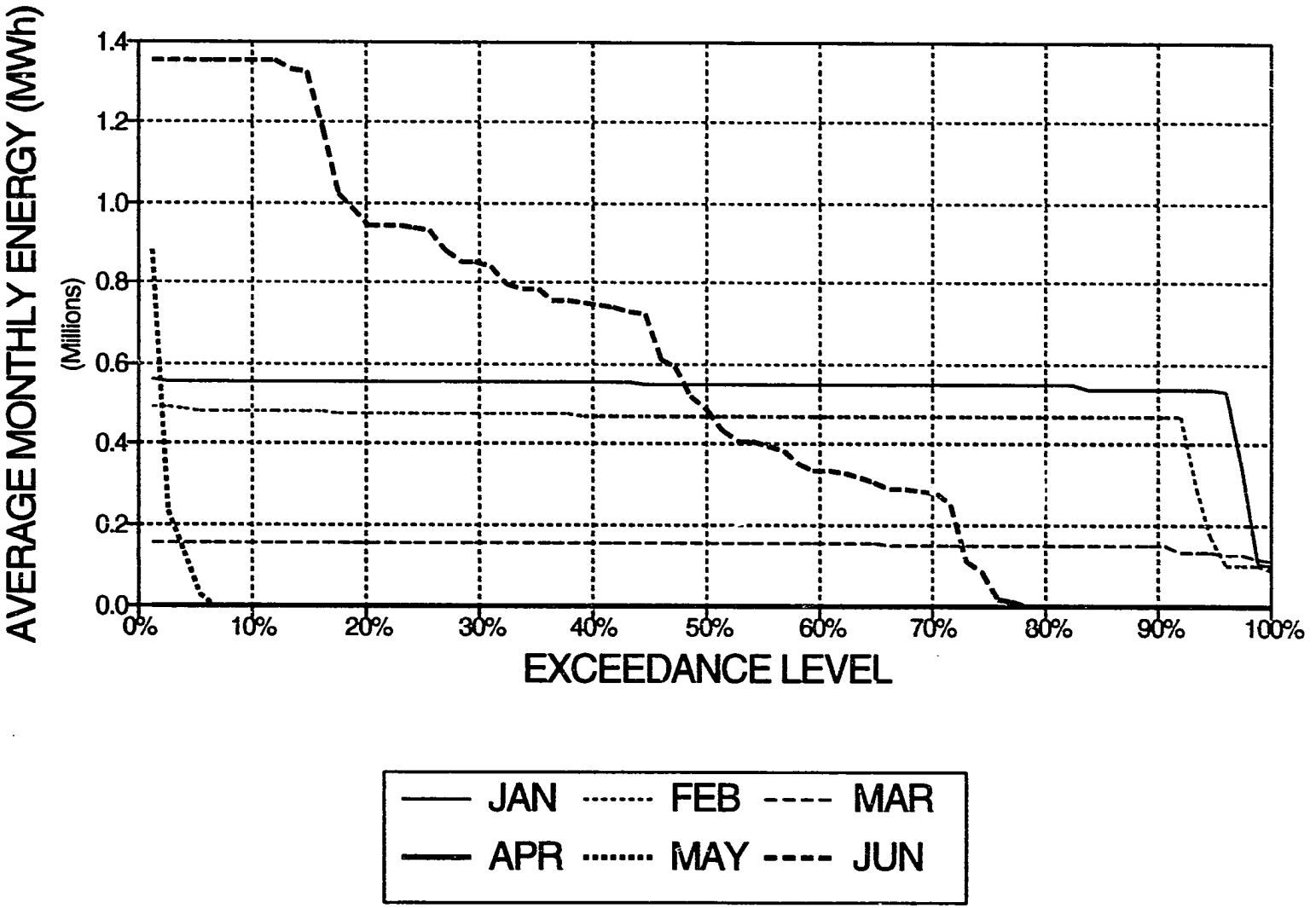


EXHIBIT 8-12

KAMBARATA #1
MONTHLY ENERGY GENERATION

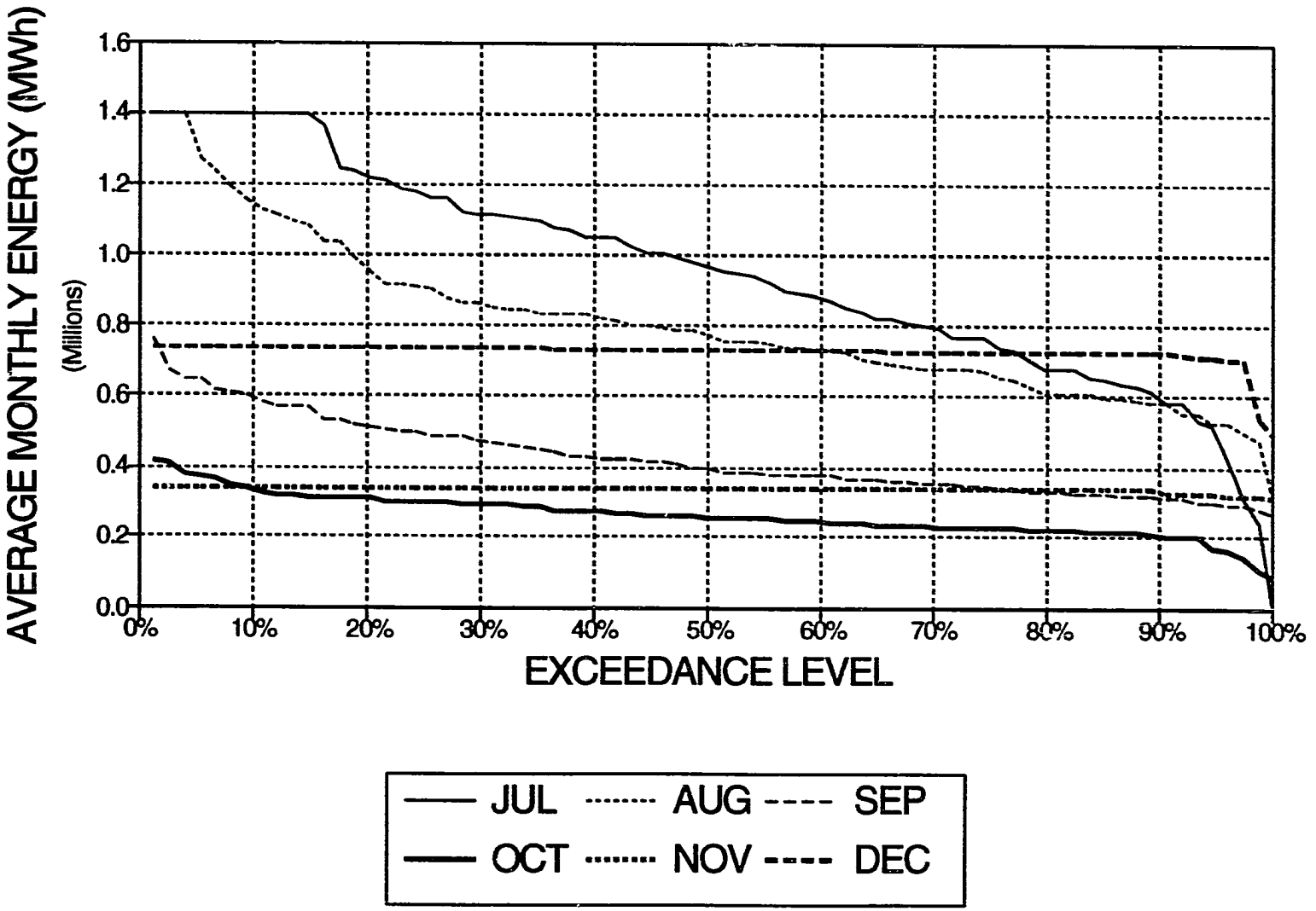


EXHIBIT 8-12

POWER ONLY SCENARIO

TOKTOGUL

MONTH	EXCEEDENCE LEVEL		
	10%	50%	90%
January	694,700	659,900	659,900
February	484,600	453,700	453,700
March	446,000	391,800	391,800
April	415,500	309,300	309,300
May	461,200	247,500	247,500
June	1,006,000	206,200	206,200
July	593,000	144,400	144,400
August	372,900	144,400	144,400
September	337,300	206,200	206,200
October	338,100	247,500	247,500
November	510,300	453,700	453,700
December	704,800	659,900	659,900
Annual	6,117,000	4,124,500	4,124,500

KURPSAI

MONTH	EXCEEDENCE LEVEL		
	10%	50%	90%
January	450,000	409,900	3
February	323,900	295,000	2
March	292,500	266,800	2
April	279,900	222,200	2
May	324,700	209,100	1
June	698,800	173,800	1
July	377,100	117,800	1
August	240,400	109,600	1
September	218,300	134,000	1
October	202,200	160,100	1
November	302,000	284,500	2
December	431,700	403,600	3
Annual	3,729,700	2,902,600	2,6

TASHKUMYR

MONTH	EXCEEDENCE LEVEL		
	10%	50%	90%
January	254,500	233,000	223,900
February	186,700	171,800	161,800
March	175,400	160,900	151,700
April	187,500	158,300	138,000
May	227,300	159,900	135,700
June	309,200	133,000	102,200
July	226,200	87,410	74,320
August	150,900	76,420	68,560
September	134,100	86,420	80,400
October	123,300	101,300	93,550
November	178,600	166,[illegible]	156,400
December	246,300	231,[illegible]00	220,800
Annual	2,266,500	1,813,790	1,615,970

SHAMALDYSAI

MONTH	EXCEEDENCE LEVEL		
	10%	50%	90%
January	133,800	122,100	117,300
February	97,720	89,900	84,630
March	91,750	84,100	79,230
April	98,110	82,720	70,970
May	119,100	83,550	70,780
June	176,900	60,430	53,090
July	118,500	45,330	38,690
August	78,810	39,780	35,700
September	70,010	44,800	41,820
October	64,270	52,670	48,500
November	93,420	87,220	81,740
December	129,300	121,100	115,700
Annual	1,187,930	947,870	843,800

UCH-KURGAN

MONTH	EXCEEDENCE LEVEL		
	10%	50%	90%
January	145,300	132,900	127,800
February	107,000	98,780	93,130
March	101,000	92,660	87,420
April	107,500	91,100	78,420
May	129,700	92,070	78,250
June	136,800	76,730	[illegible],000
July	129,000	50,820	43,010
August	86,970	44,440	39,130
September	77,370	50,200	46,840
October	71,150	58,660	54,240
November	102,600	95,990	90,050
December	140,500	131,800	126,100
Annual	1,273,770	1,042,810	929,110

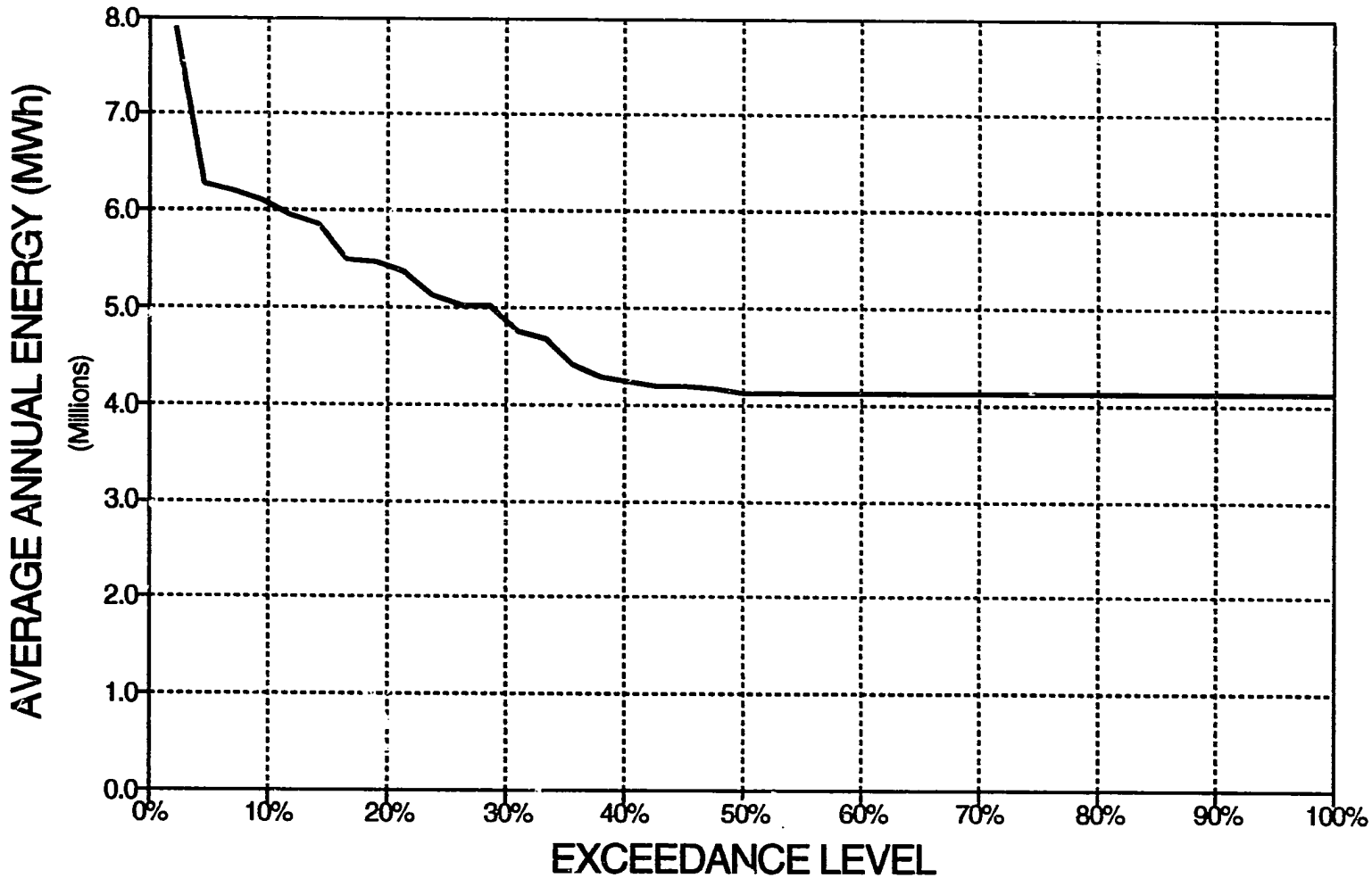
KAMBARATA #2

MONTH	EXCEEDENCE LEVEL		
	10%	50%	90%
January	51,550	42,500	36,250
February	46,320	37,910	32,970
March	57,120	48,130	40,640
April	102,600	72,170	47,980
May	230,900	153,100	104,400
June	259,400	239,000	140,900
July	267,200	216,200	155,300
August	239,700	160,500	131,000
September	126,100	[illegible]4,990	70,500
October	79,080	61,990	53,850
November	61,550	51,790	44,750
December	57,120	43,990	37,710
Annual	1,507,440	1,185,170	968,920

KAMBARATA #1

MONTH	EXCEEDENCE LEVEL		
	10%	50%	90%
January	500,200	461,500	461,500
February	437,000	401,500	401,500
March	392,400	360,200	360,200
April	393,500	295,100	281,400
May	545,500	262,600	262,600
June	1,178,000	686,100	221,400
July	1,004,000	472,800	198,900
August	762,400	386,000	198,900
September	482,400	[illegible]43,400	0
October	284,000	262,600	0
November	[illegible]58,100	405,900	401,500
December	531,000	480,300	480,300
Annual	3,376,200	4,665,500	3,791,800

TOKTOGUL #1
ANNUAL ENERGY GENERATION



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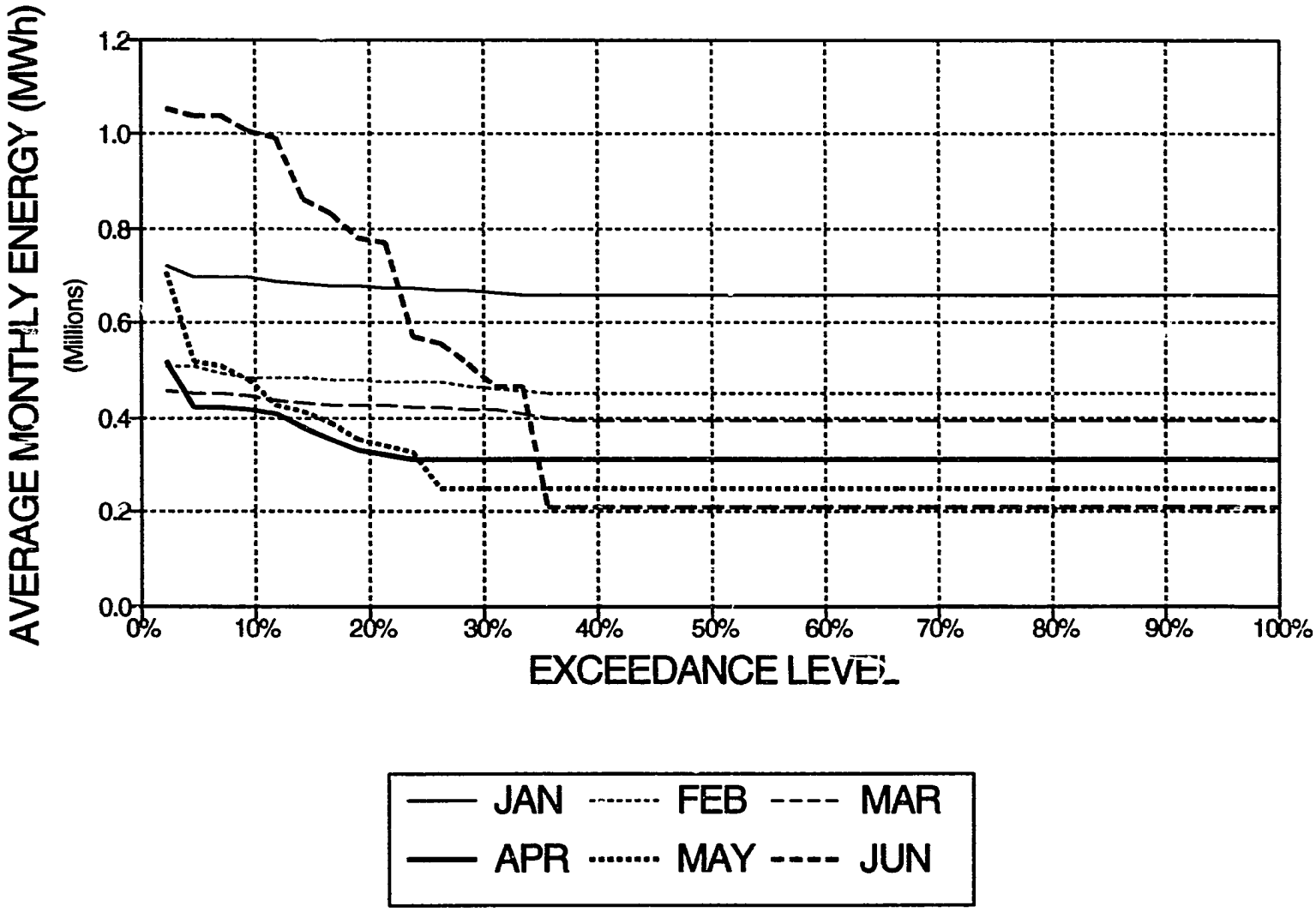
MONTHLY ENERGY GENERATION



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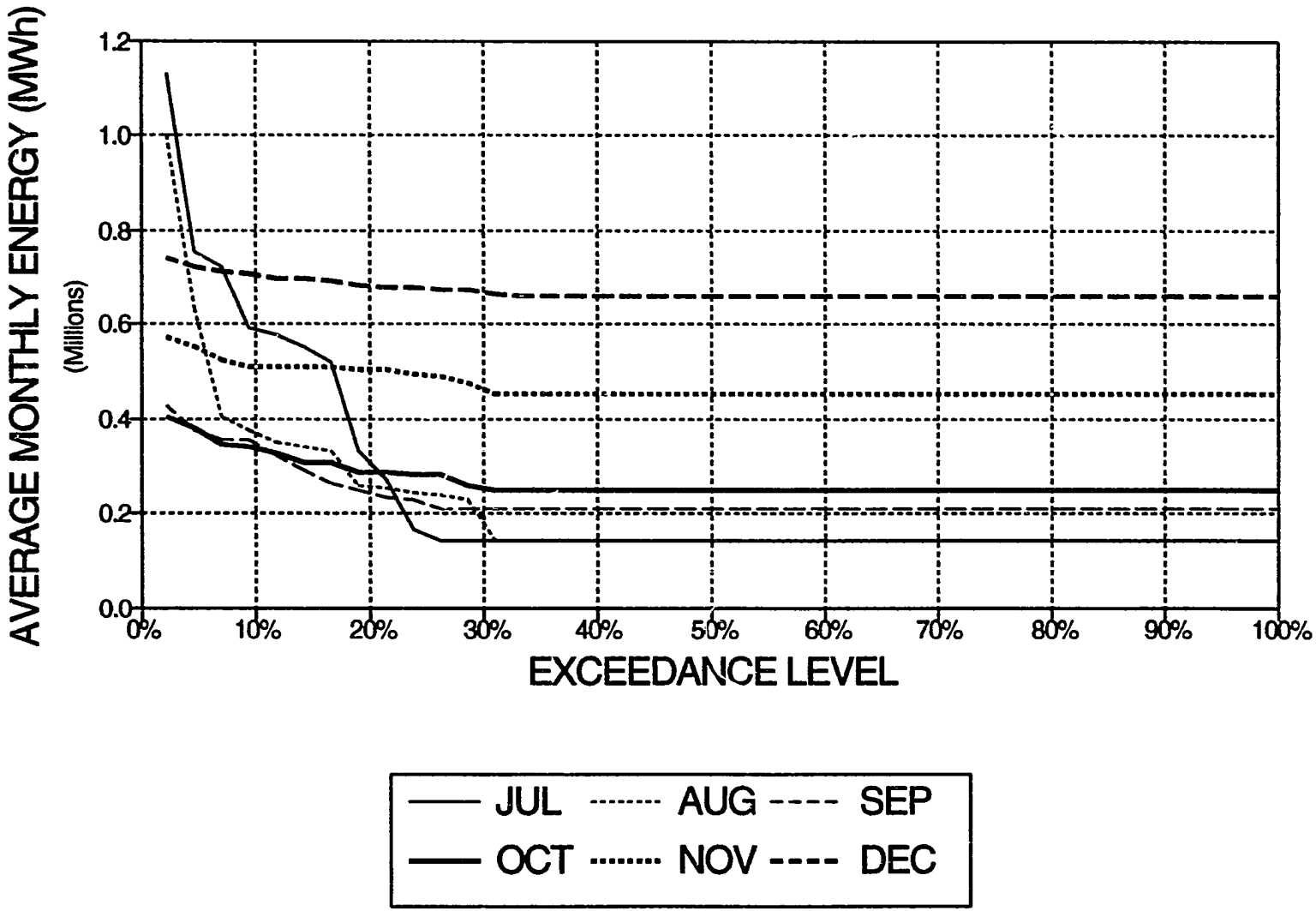

KURPSAI
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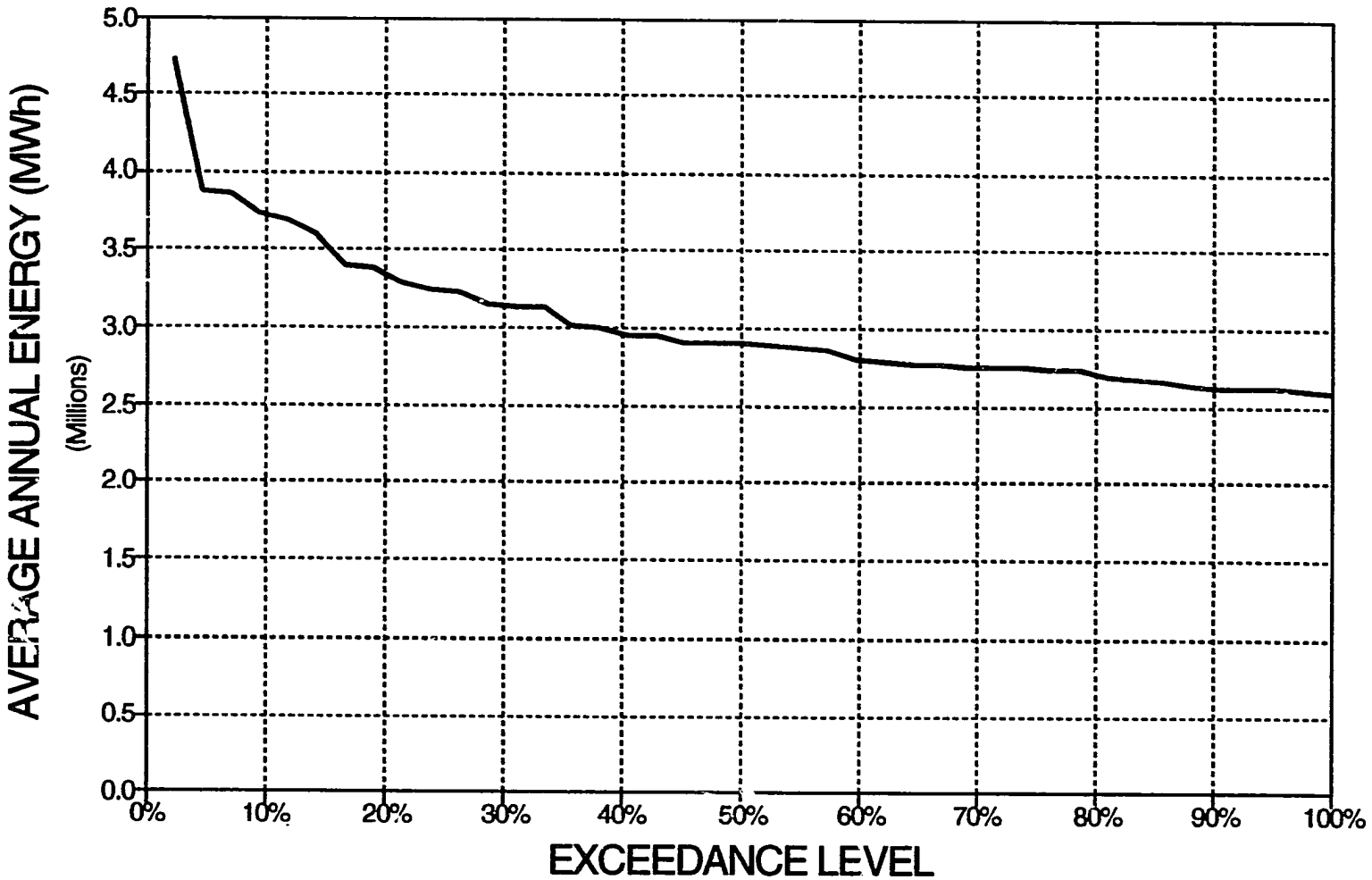

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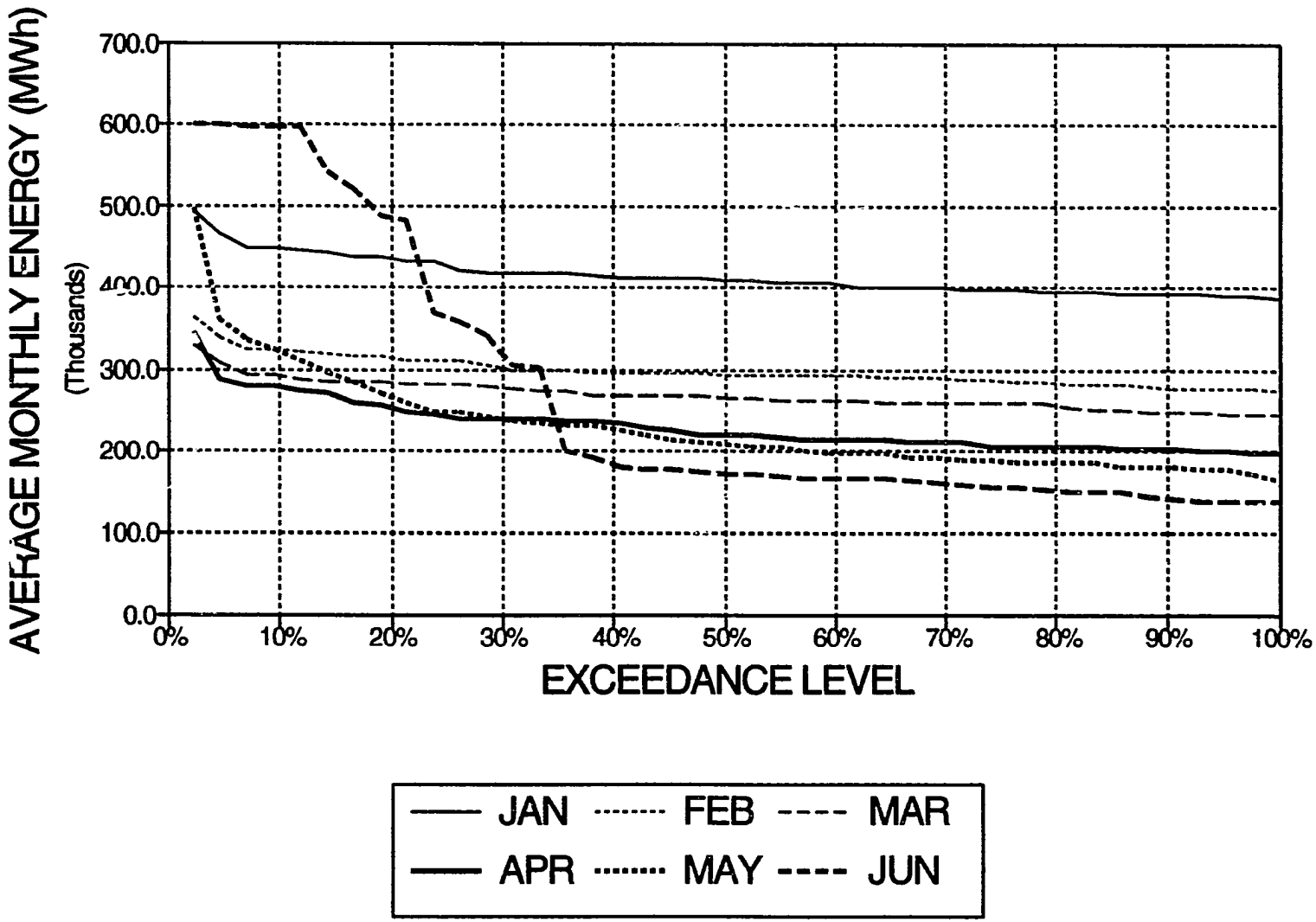

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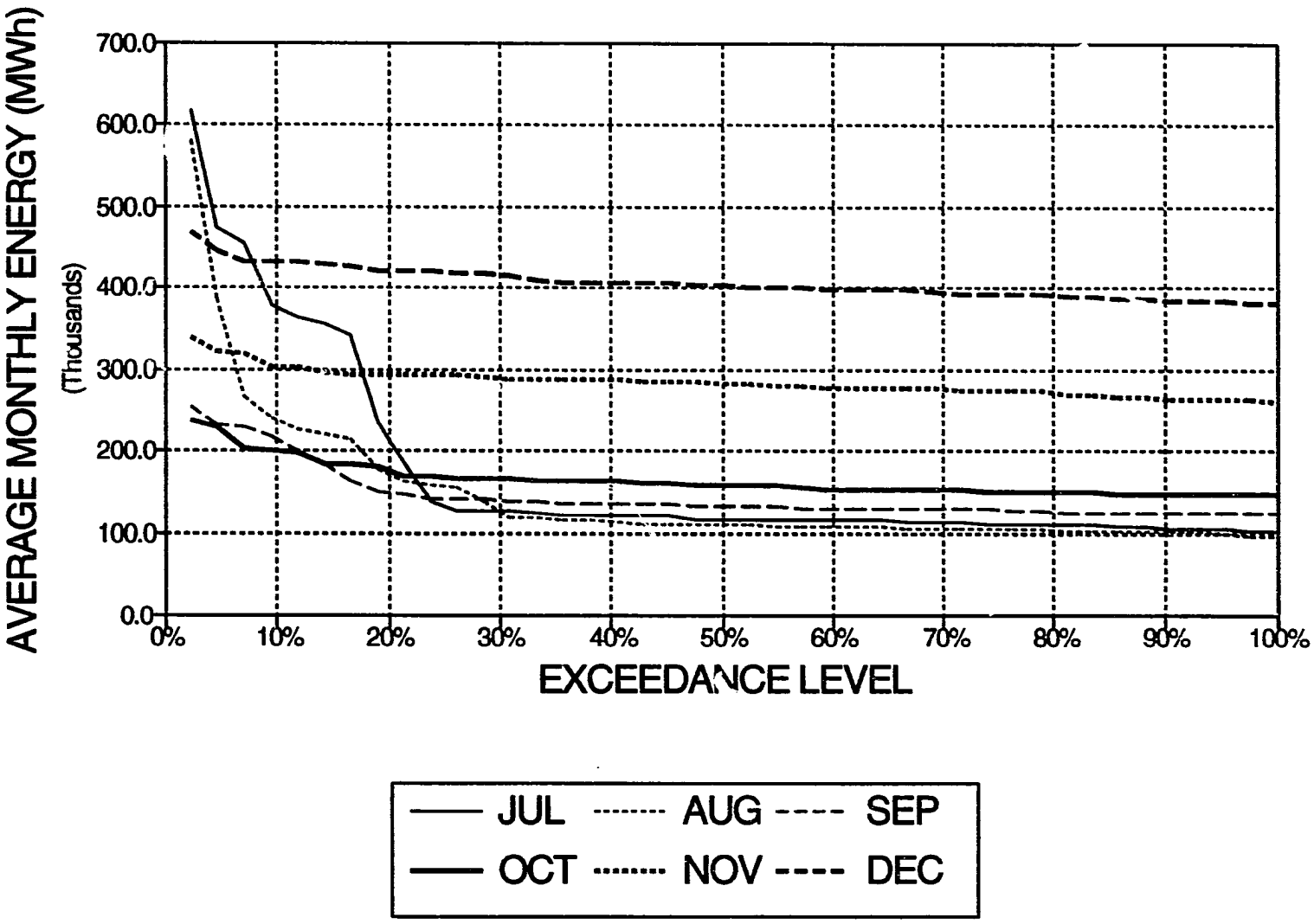


EXHIBIT 8-15

TASHKUMYR
ANNUAL ENERGY GENERATION

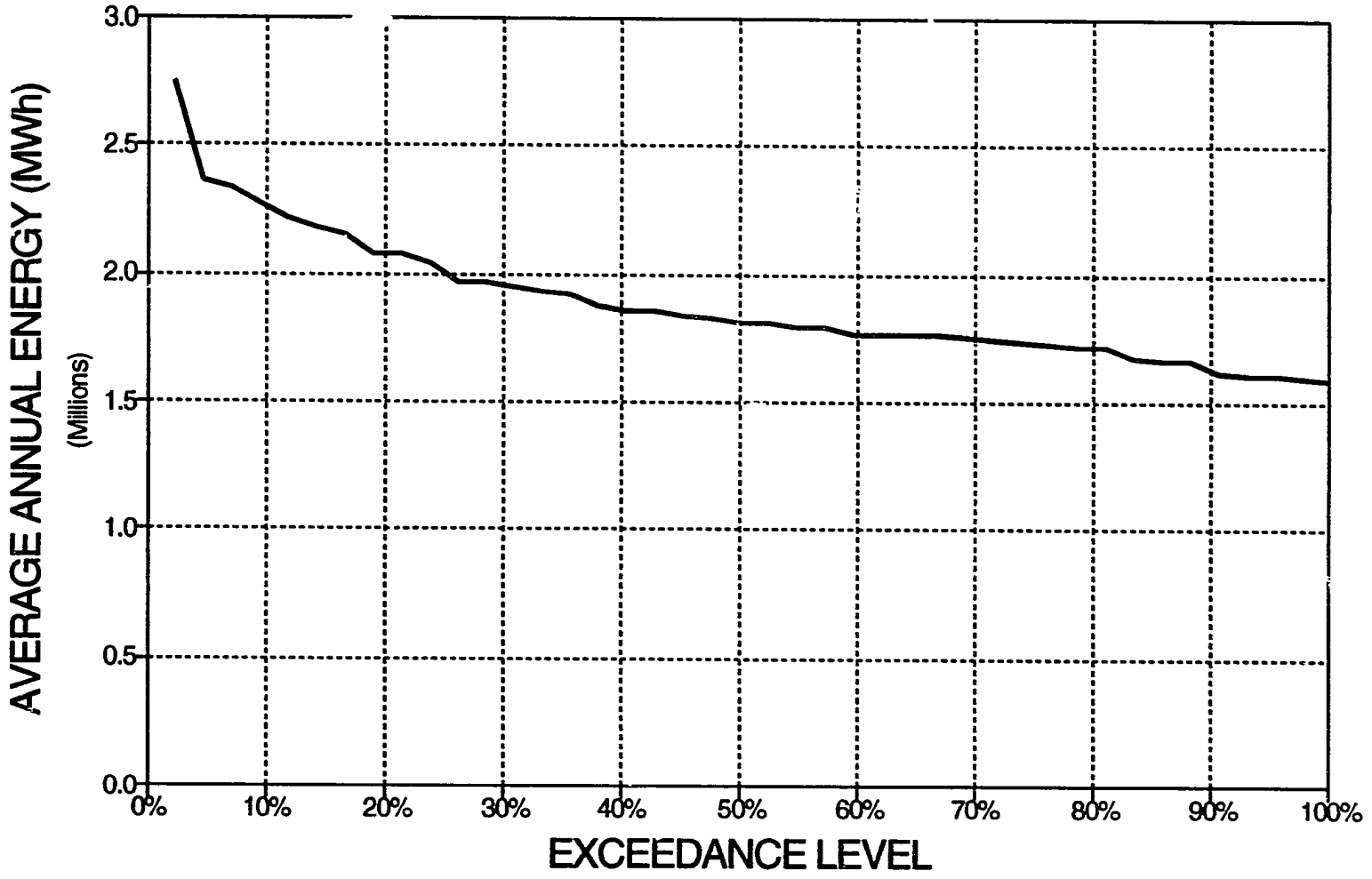


EXHIBIT 8-16

TASHKUMYR
MONTHLY ENERGY GENERATION

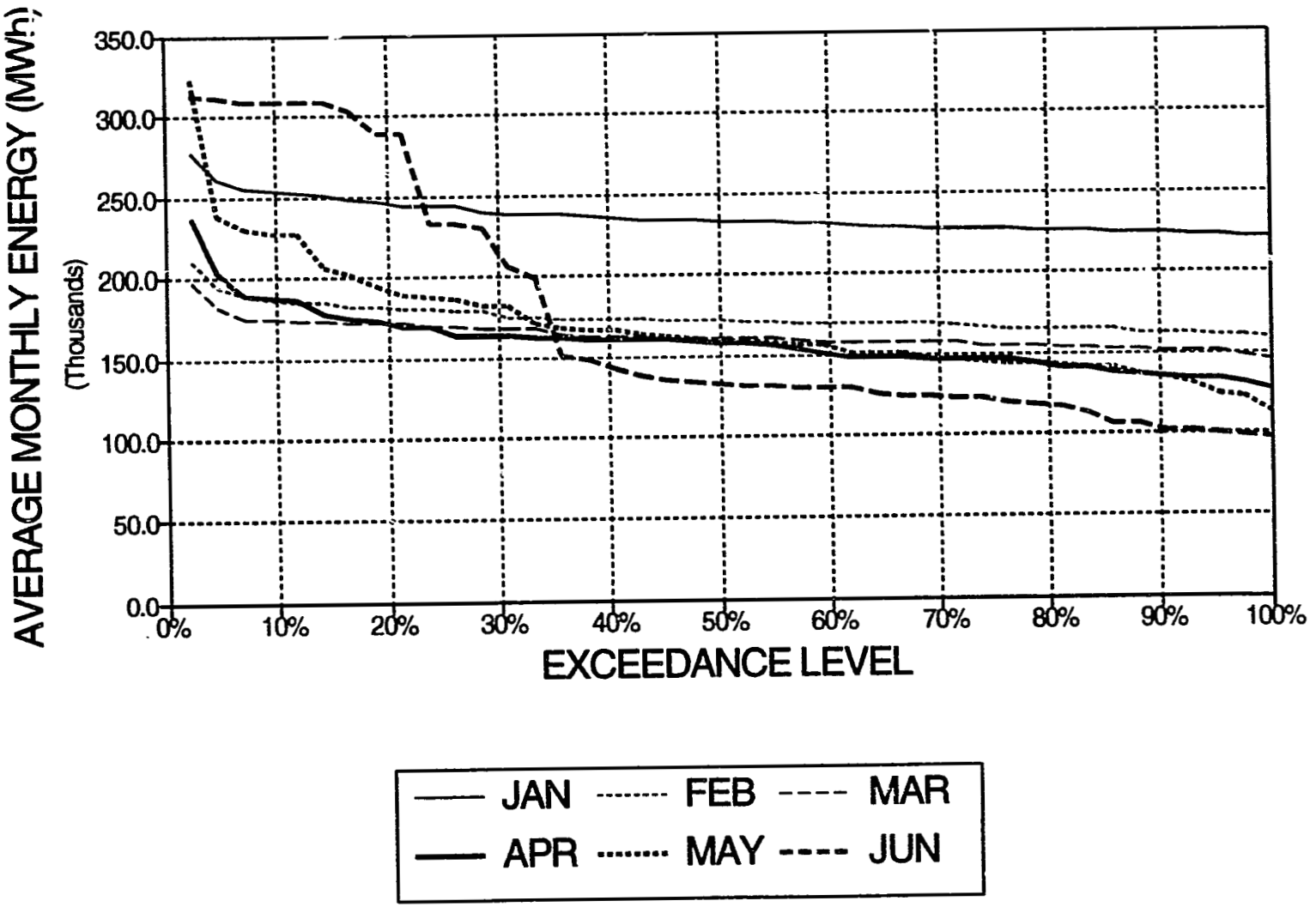
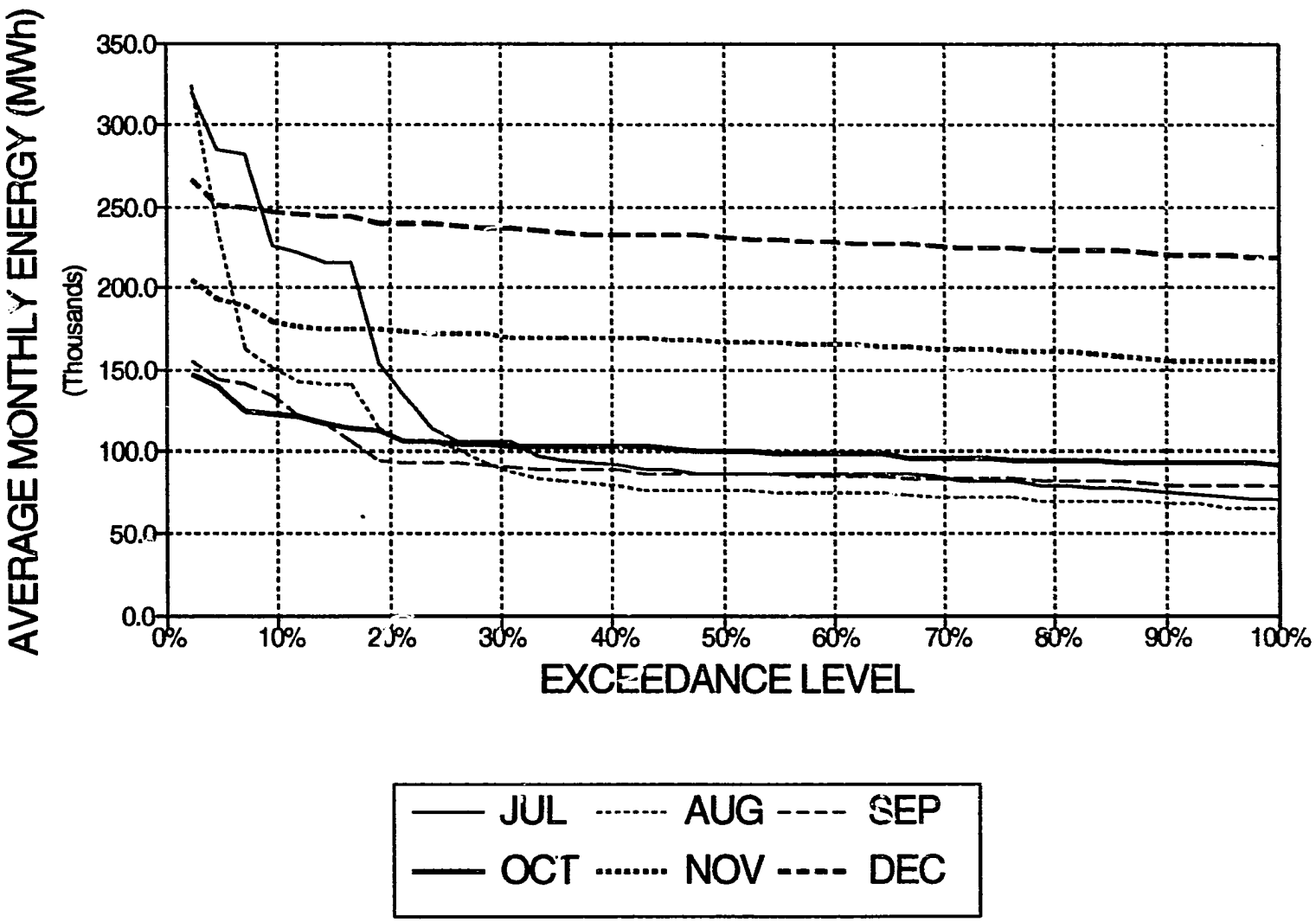


EXHIBIT 8-16

TASHKUMYR
MONTHLY ENERGY GENERATION



SHAMALDYSAI
ANNUAL ENERGY GENERATION

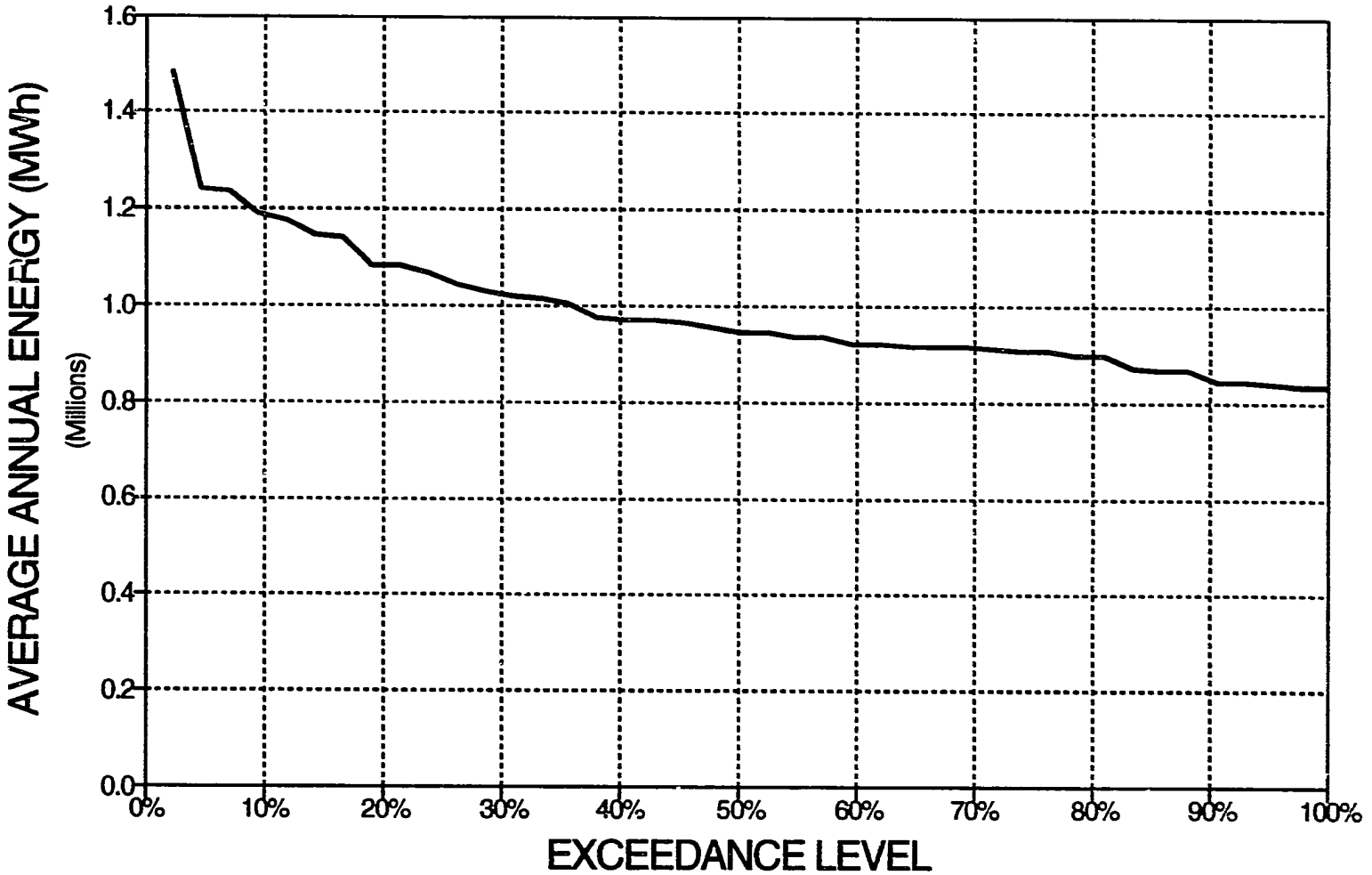


EXHIBIT 8-17

SHAMALDYSAI
MONTHLY ENERGY GENERATION

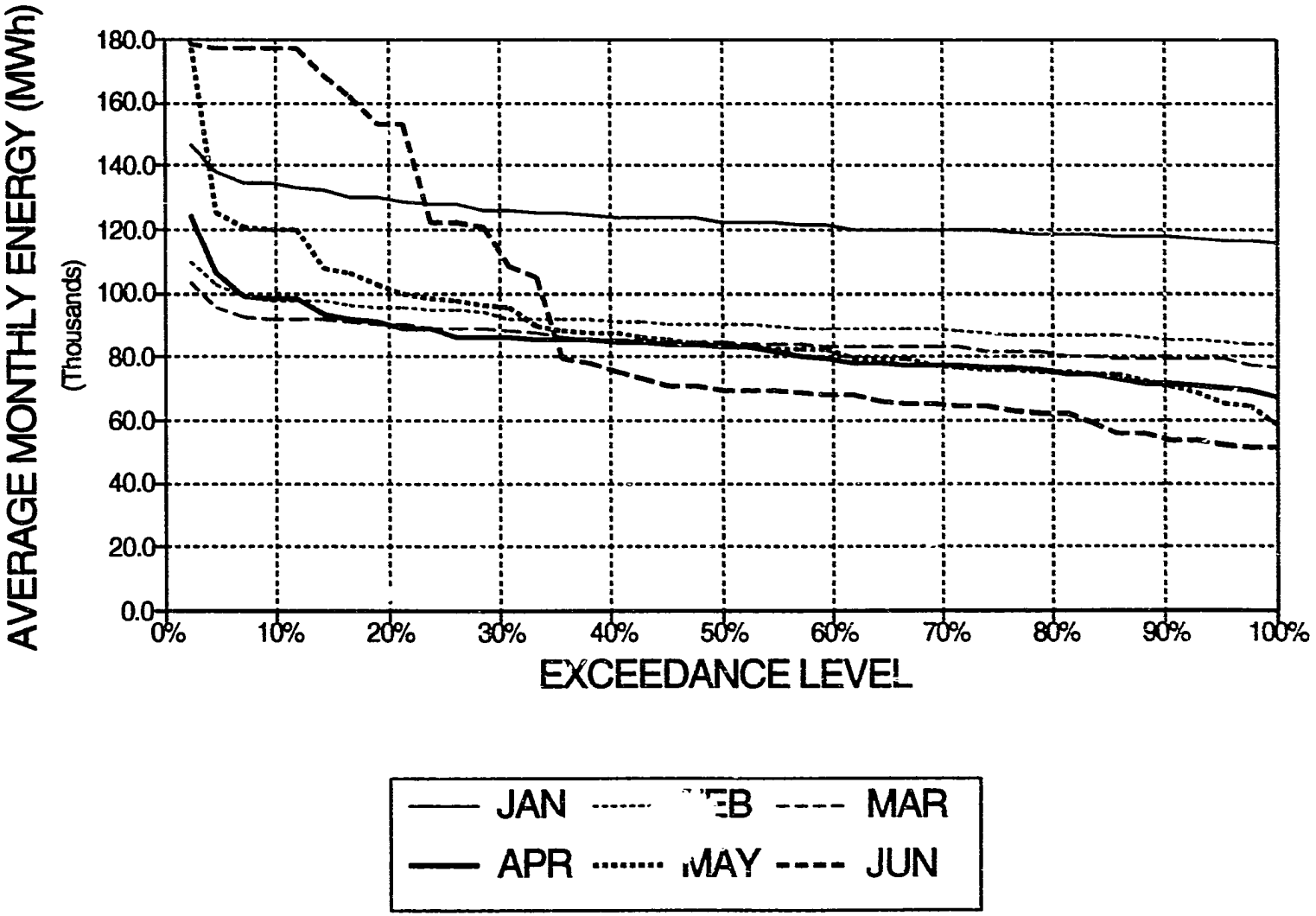
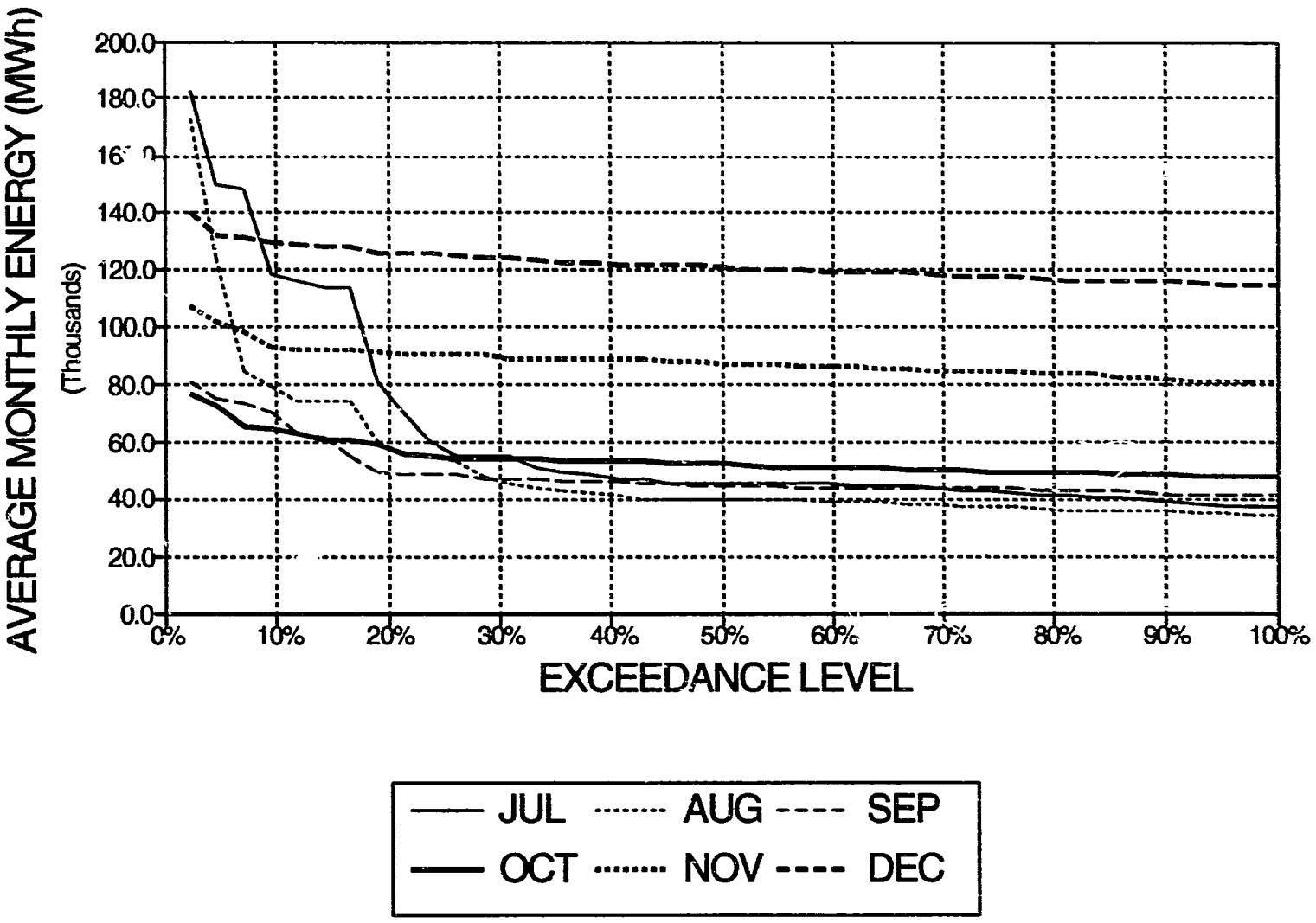
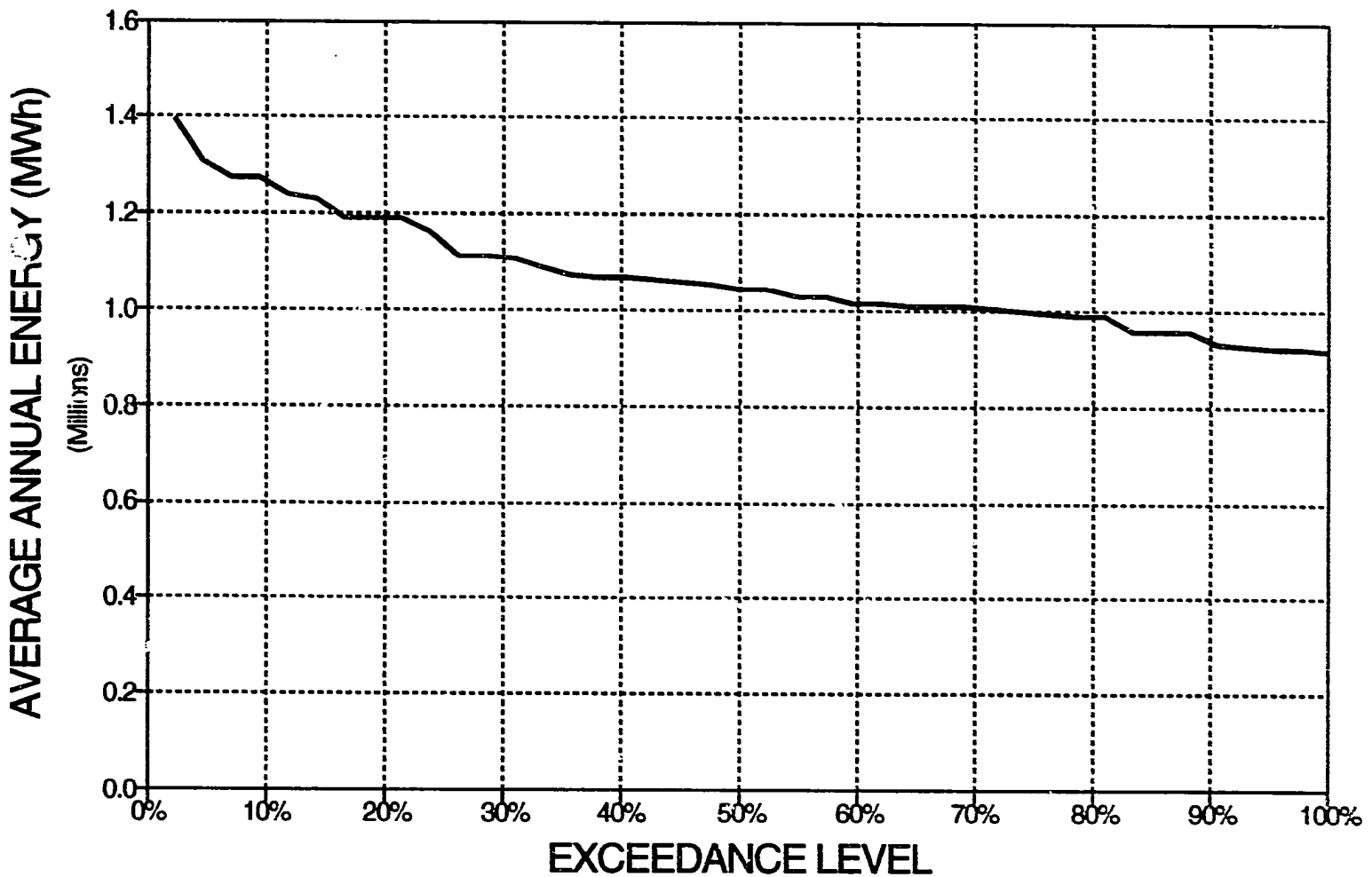


EXHIBIT 8-17

SHAMALDYSAI
MONTHLY ENERGY GENERATION



UCH-KURGAN
ANNUAL ENERGY GENERATION



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MONTHLY ENERGY GENERATION

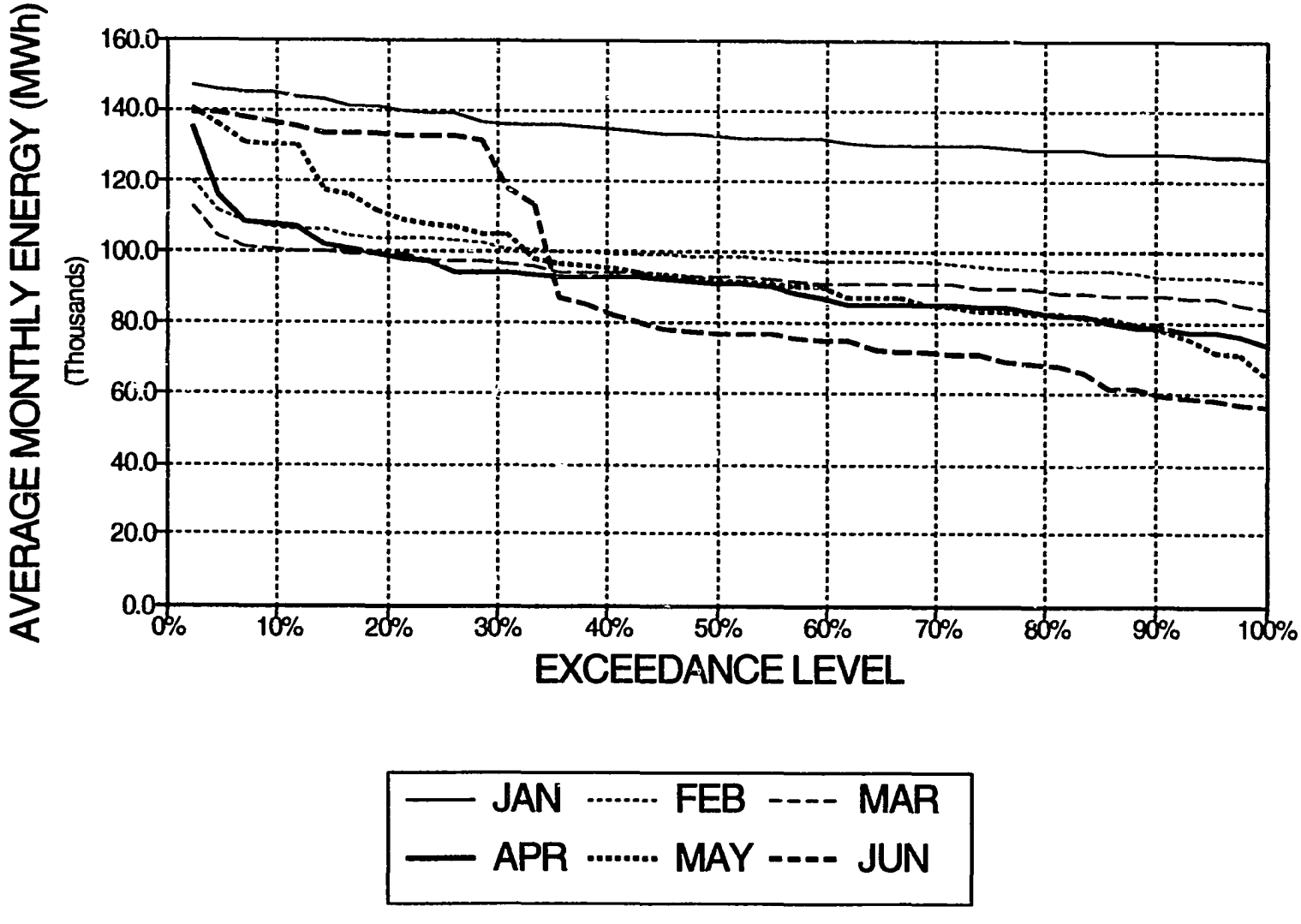


EXHIBIT 8-18

UCH-KURGAN
MONTHLY ENERGY GENERATION

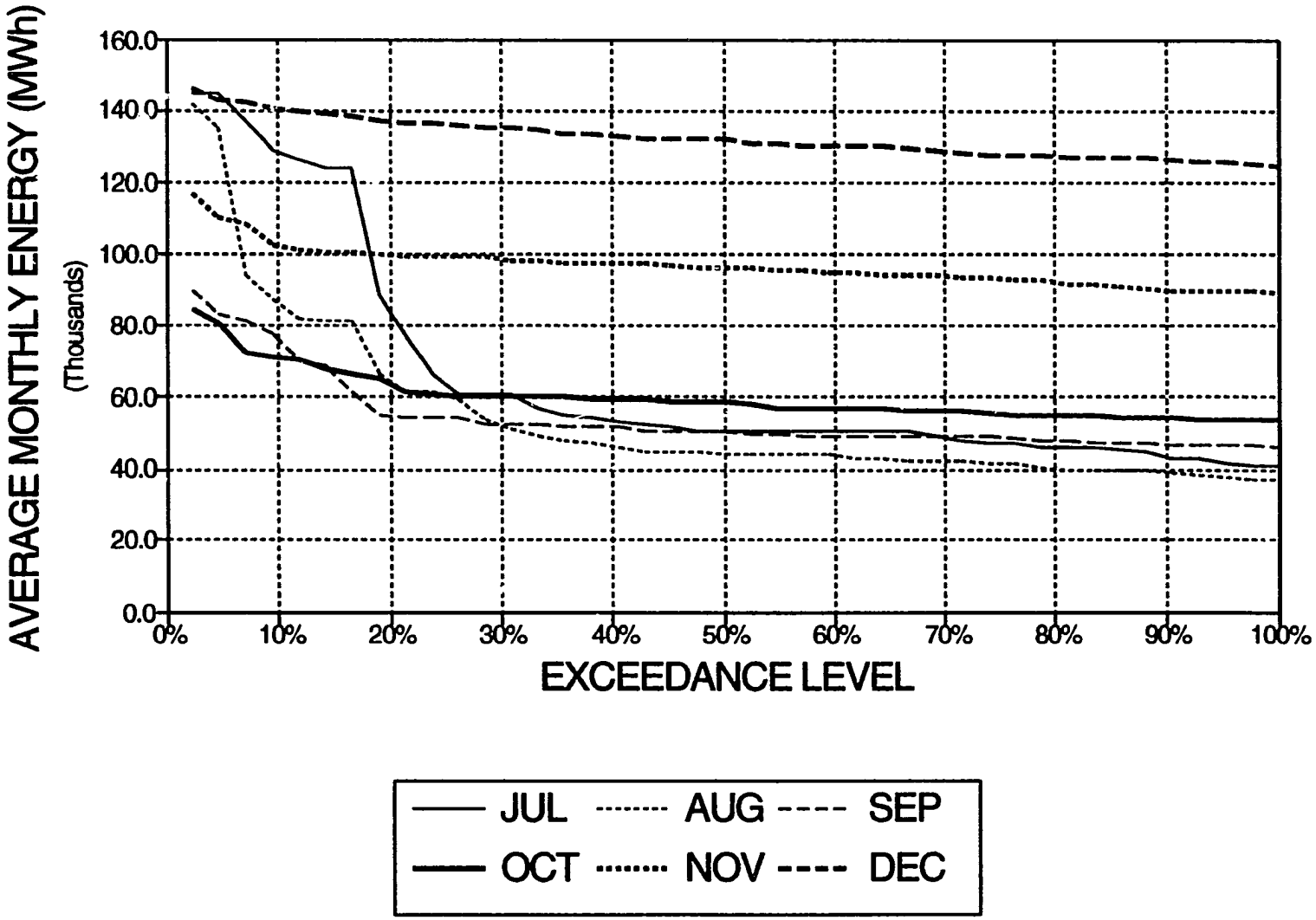


EXHIBIT 8-18

KAMBARATA #2
ANNUAL ENERGY GENERATION

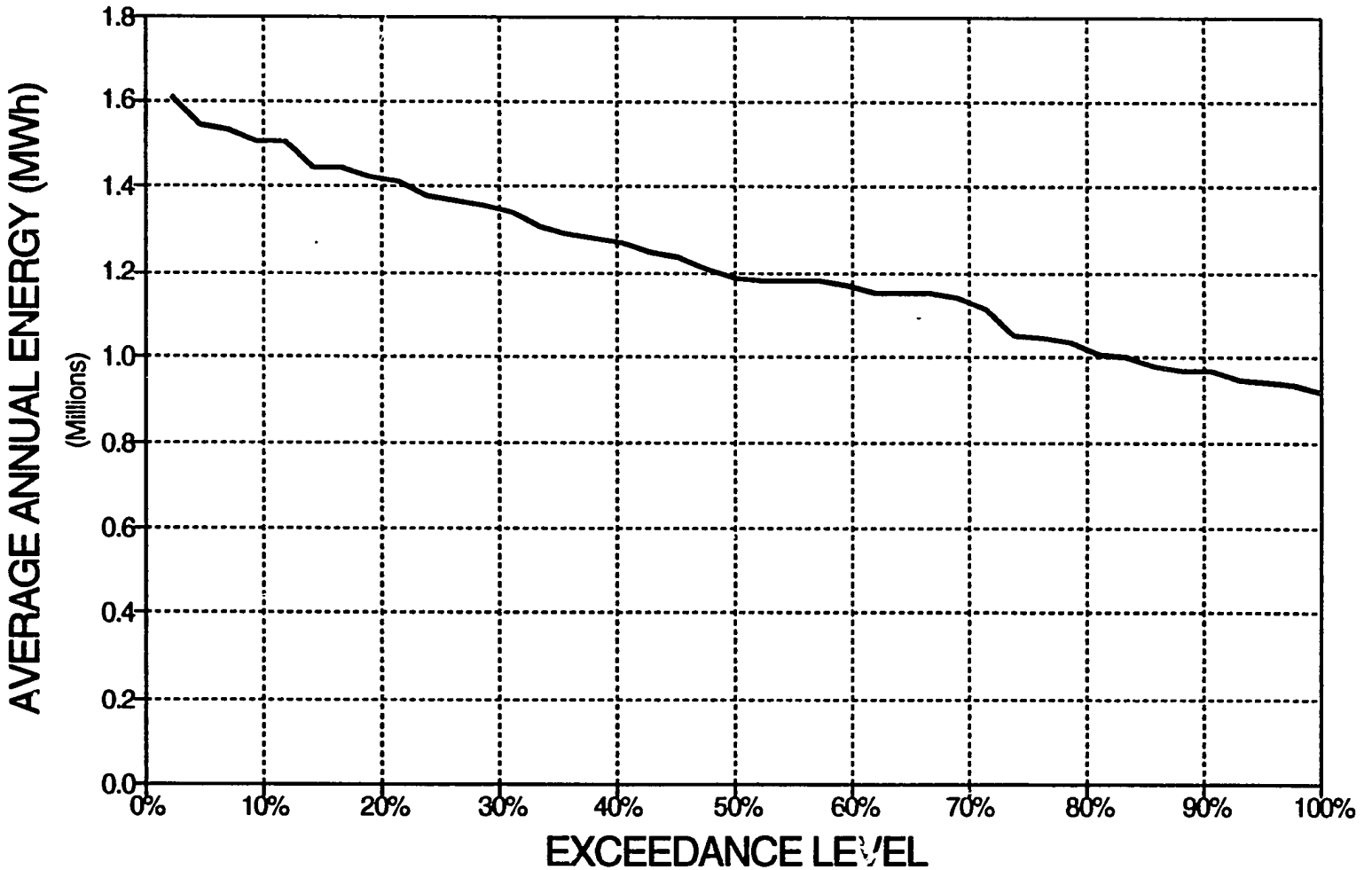


EXHIBIT 8-19

KAMBARATA #2
MONTHLY ENERGY GENERATION

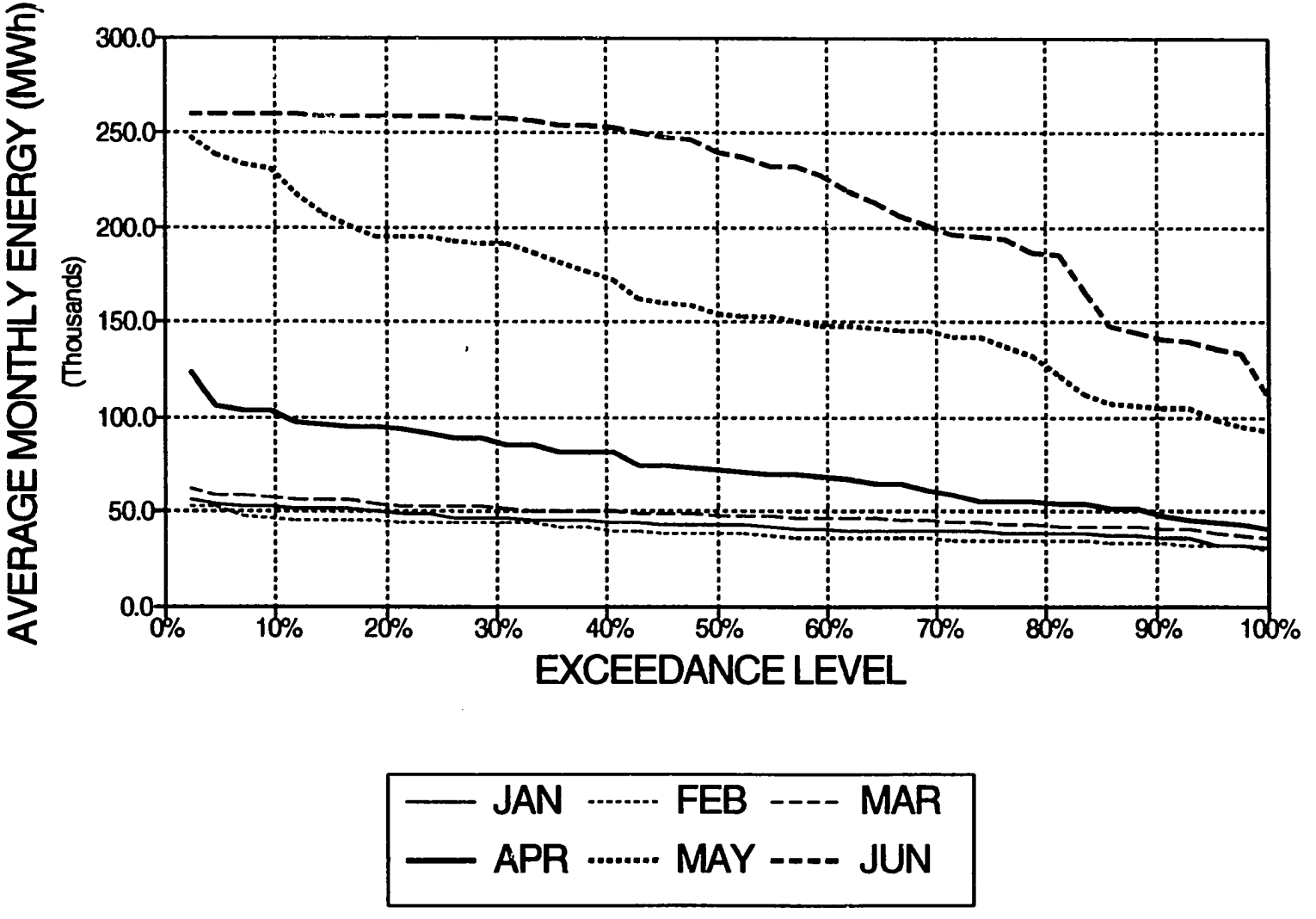


EXHIBIT 8-19

KAMBARATA #2
MONTHLY ENERGY GENERATION

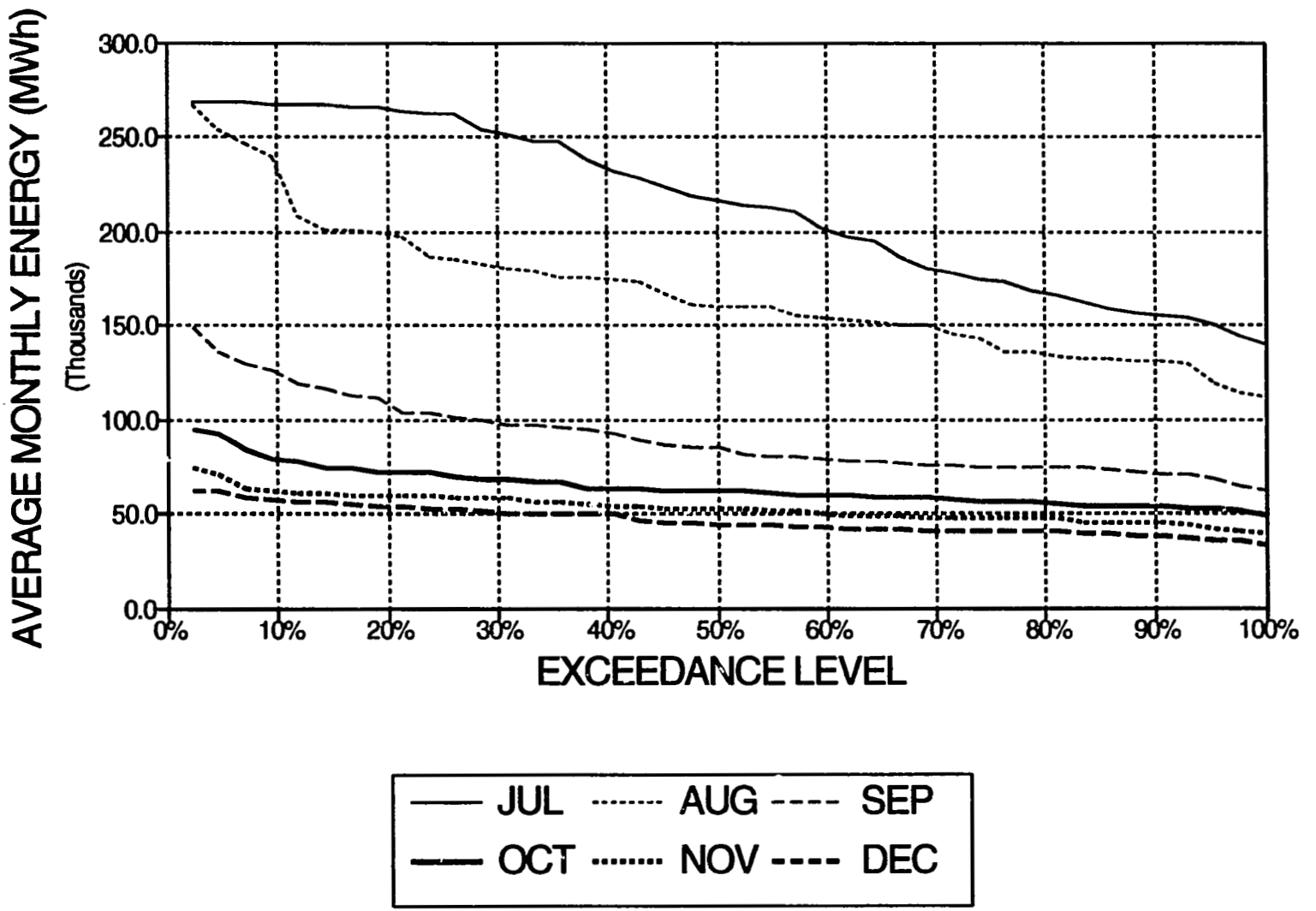


EXHIBIT 8-19

KAMBARATA #1
ANNUAL ENERGY GENERATION

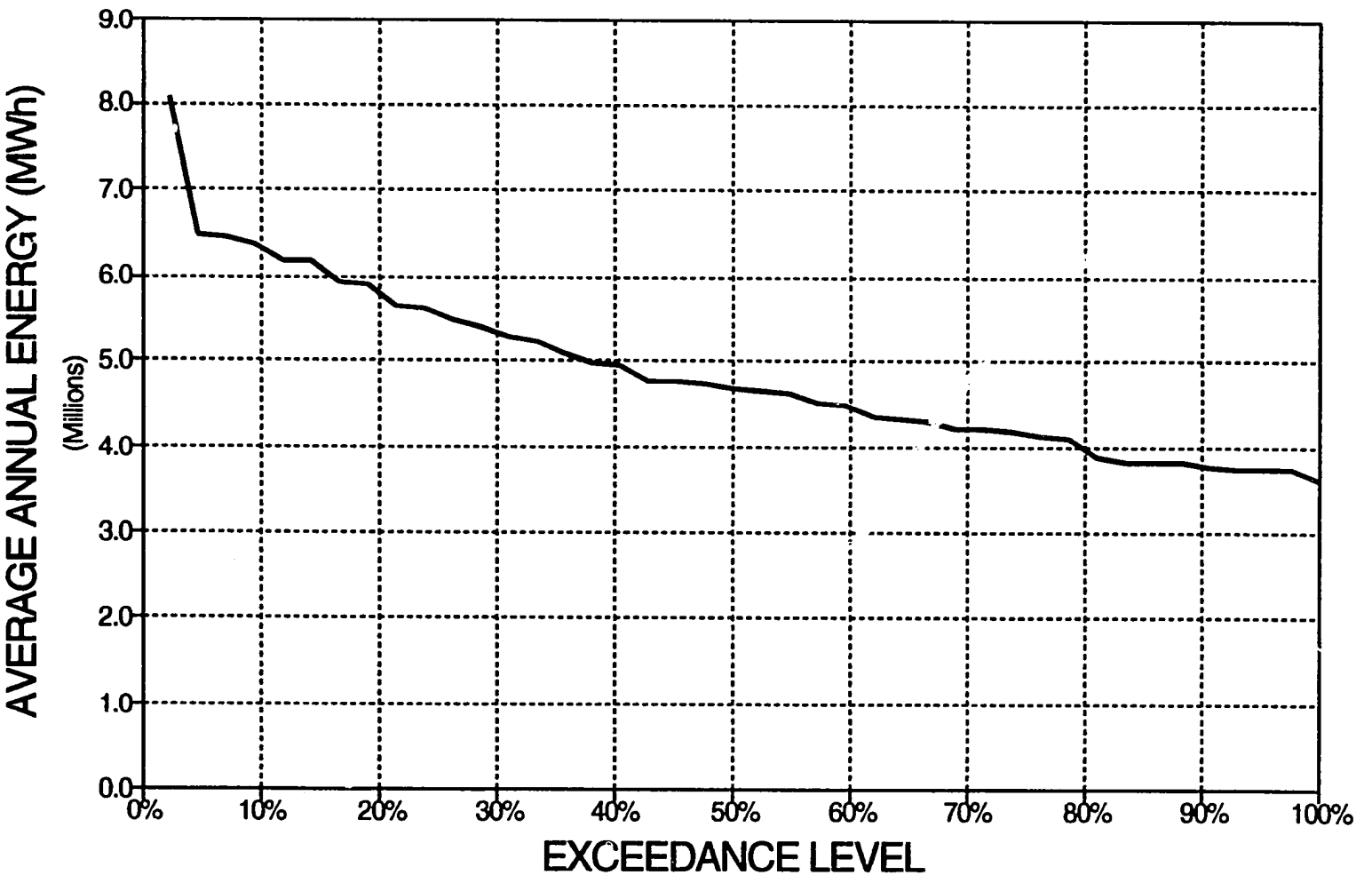
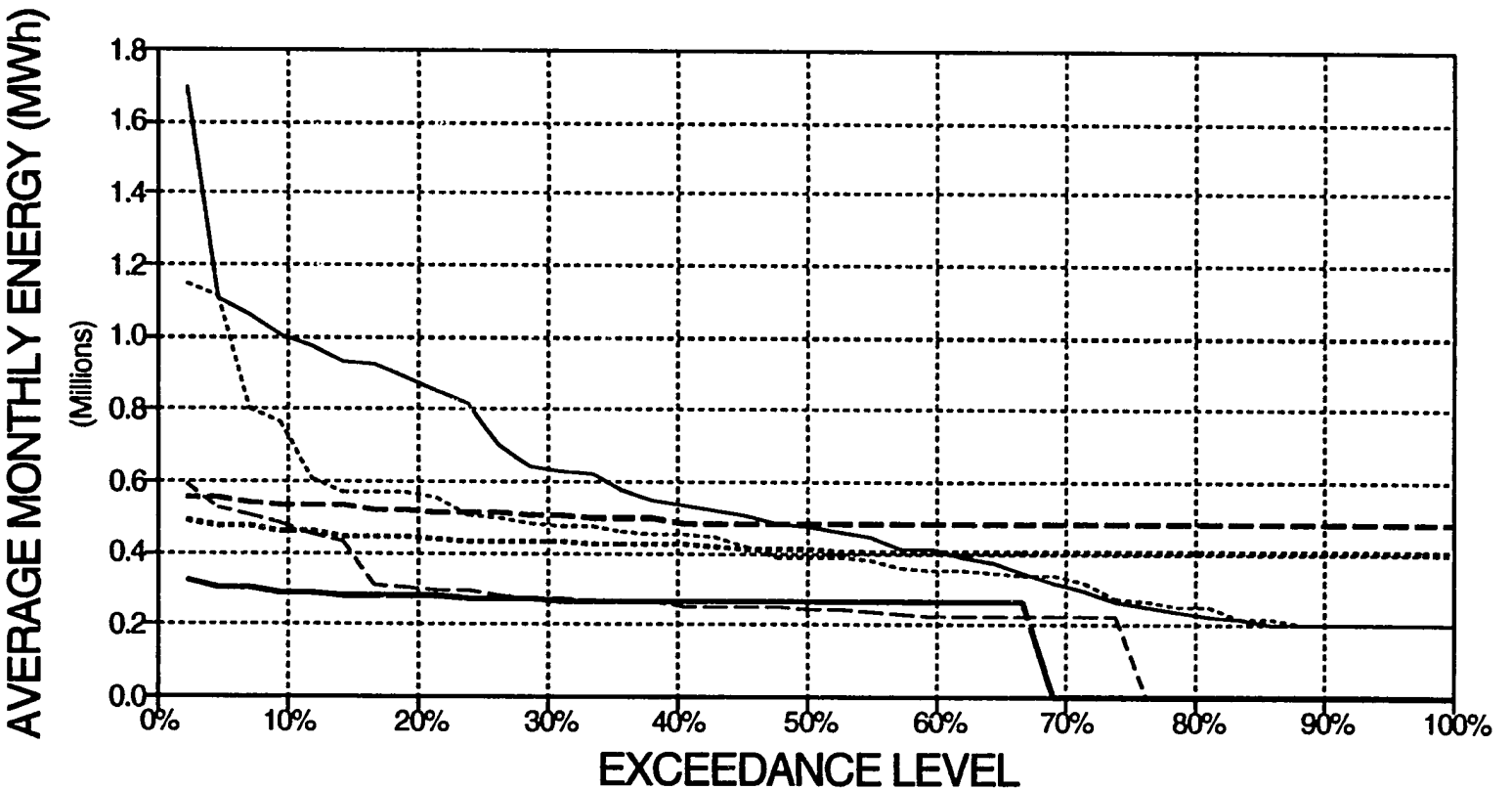


EXHIBIT 8-20

KAMBARATA #1
MONTHLY ENERGY GENERATION



—— JUL	····· AUG	---- SEP
—— OCT	····· NOV	---- DEC

EXHIBIT 8-20

KAMBARATA #1
MONTHLY ENERGY GENERATION

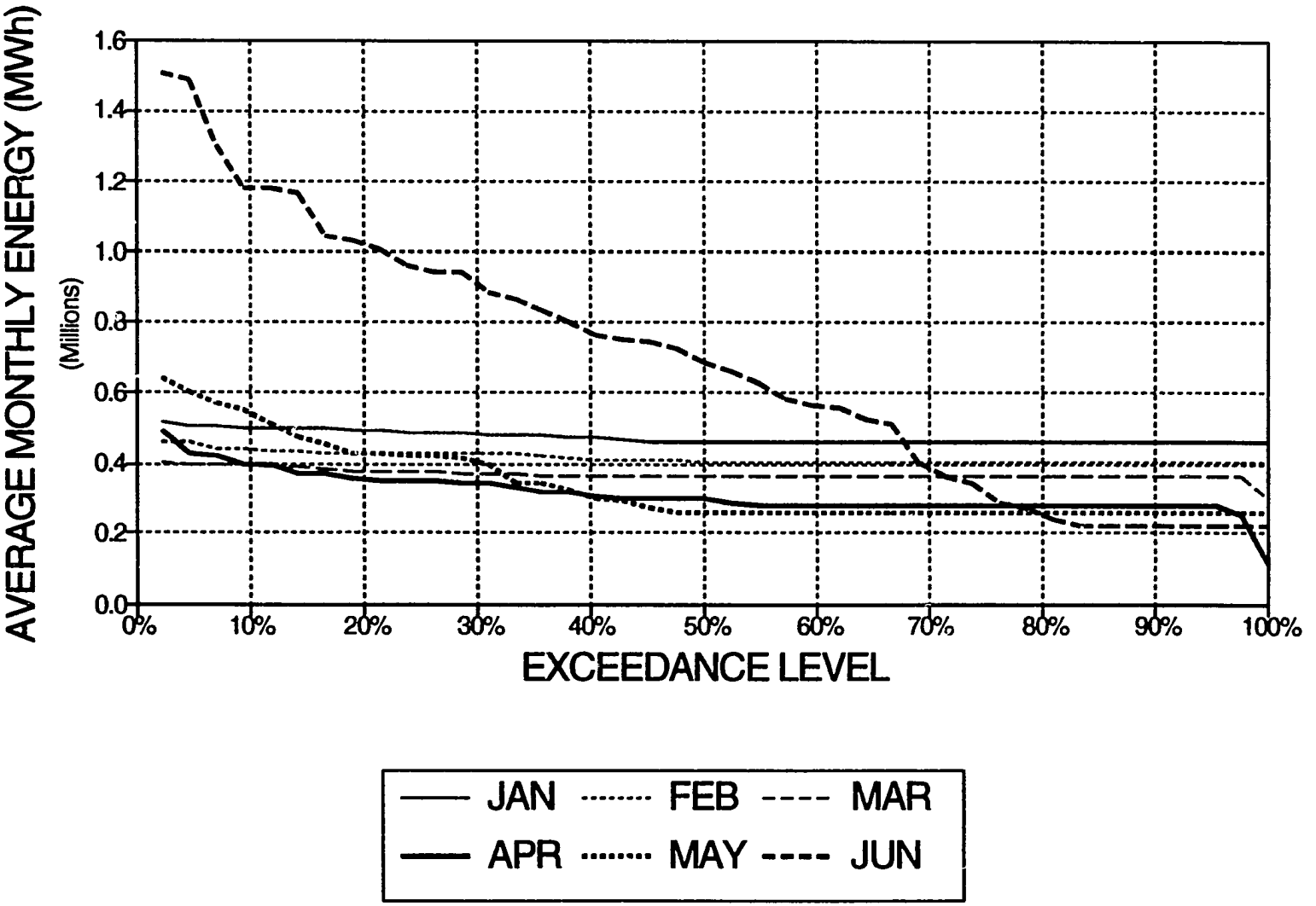


EXHIBIT 8-20

MONTHLY ENERGY GENERATION
EXISTING HYDROELECTRIC PROJECTS

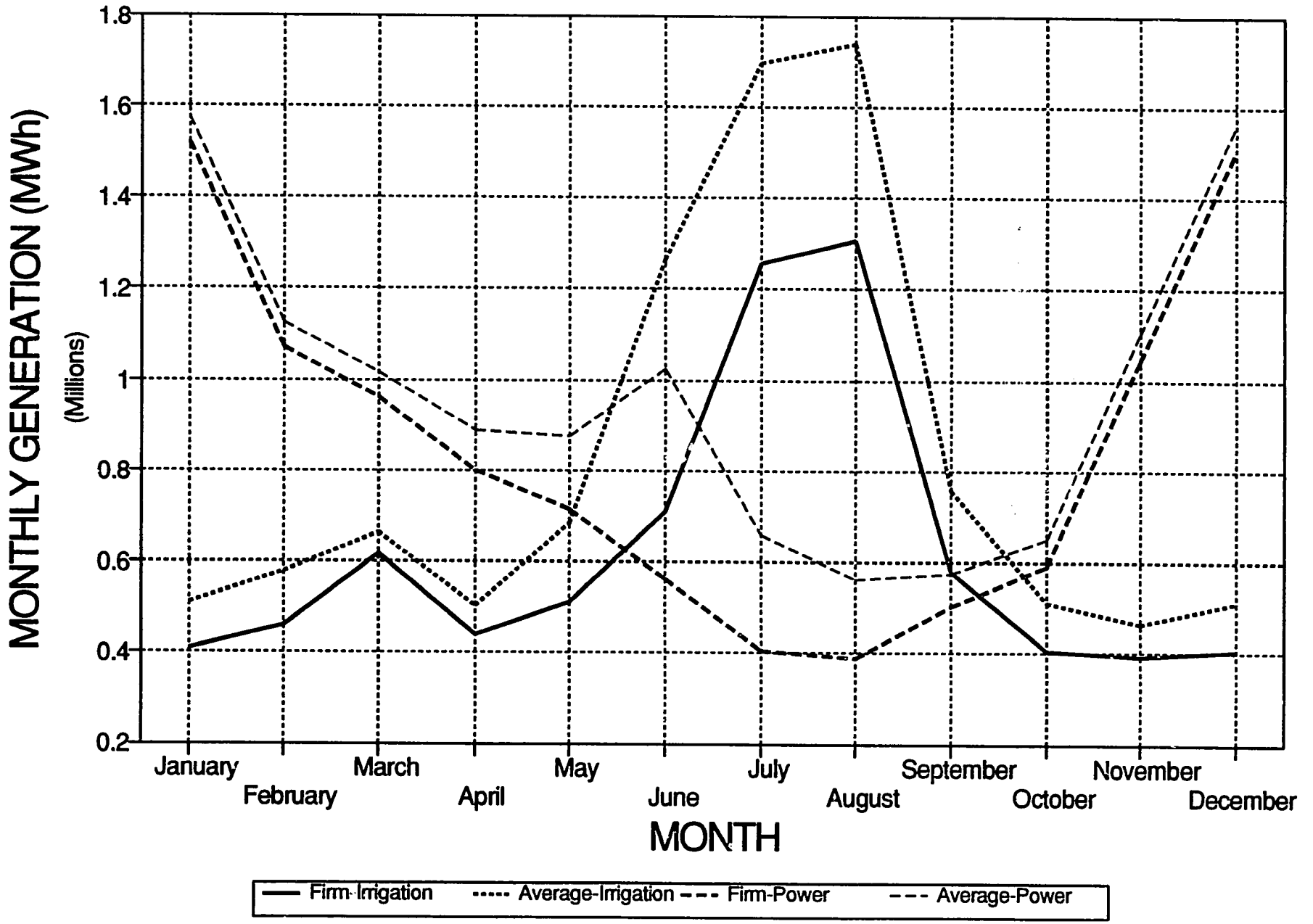


EXHIBIT 8-21

MONTHLY ENERGY GENERATION

EXISTING PROJECTS & KAMBARATA 1 AND 2

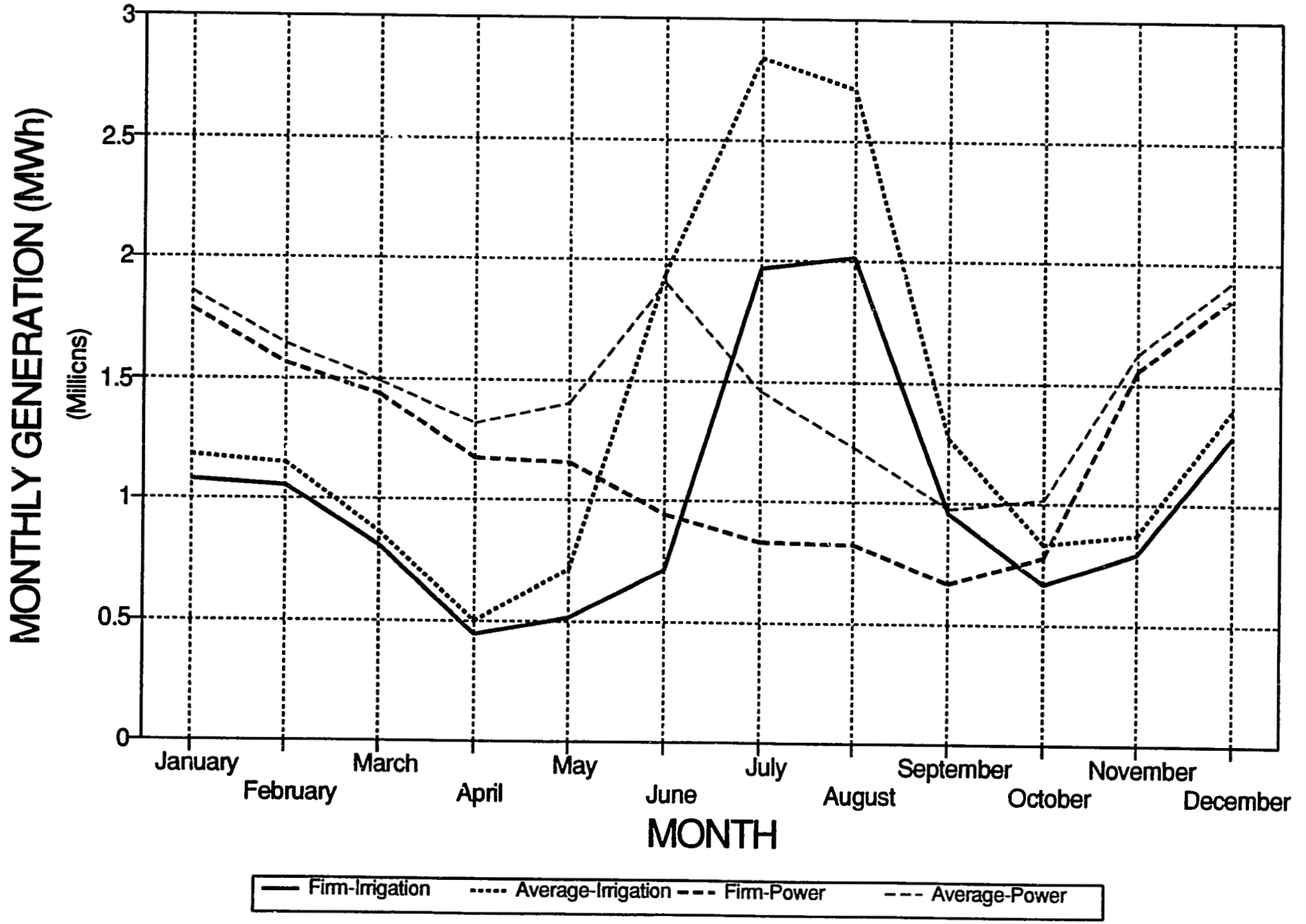


EXHIBIT 8-22

PROJECT NAME: KAMBARATA 2 INITIAL PHASE OF 240 MW

Installed Capacity (MW)	240.0	Thermal Capacity Cost(\$/kW)	1300	Construction Cost	HYDRO	COAL
Dependable Capacity (MW)	58.0	Fixed O&M Cost (\$/kW-yr)	25	YEAR 1	30%	5%
Hydro Mechanical Availability	1.237	Variable Coal O&M Cost (\$/MWh)	2.5	YEAR 2	50%	25%
Hydro Energy Generation (GWh)	1072	Variable CCGT O&M Cost (\$/MWh)	3.5	YEAR 3	20%	45%
Coal Energy Generation (GWh)	486	Coal Energy Value (\$/MWh)	20	YEAR 4		25%
Construction Cost (\$*1000)	230,700	CCGT Energy Value (\$/MWh)	30	TOTAL	100%	100%
O&M Cost (\$/kW/year)	10.0	Discount Rate	12.0%			

	HYDROPOWER COSTS					THERMAL COSTS							
YEAR	Const. Cost	O&M Cost	Total Cost	Present Worth	Cum. Present Worth	Energy Gen.	Thermal Const. Cost	Fixed O&M Cost	Energy Cost	Variable O&M Cost	Total Cost	Present Worth	Cum. Present Worth
	69,210		69,210	49,262	49,262		4,663				4,663	3,319	3,319
	115,350		115,350	73,307	122,569		23,317				23,317	14,819	18,138
	46,140		46,140	26,181	148,750		41,971				41,971	23,816	41,954
1		2,400	2,400	1,216	149,966	1,072	23,317	1,794	26,298	3,166	54,575	27,649	69,603
2		2,400	2,400	1,086	151,052	1,072		1,794	26,298	3,166	31,258	14,139	83,743
3		2,400	2,400	969	152,021	1,072		1,794	26,298	3,166	31,258	12,624	96,367
4		2,400	2,400	865	152,887	1,072		1,794	26,298	3,166	31,258	11,272	107,639
5		2,400	2,400	773	153,659	1,072		1,794	26,298	3,166	31,258	10,064	117,703
6		2,400	2,400	690	154,349	1,072		1,794	26,298	3,166	31,258	8,986	126,689
7		2,400	2,400	616	154,965	1,072		1,794	26,298	3,166	31,258	8,023	134,712
8		2,400	2,400	550	155,515	1,072		1,794	26,298	3,166	31,258	7,163	141,876
9		2,400	2,400	491	156,007	1,072		1,794	26,298	3,166	31,258	6,396	148,272
10		2,400	2,400	438	156,445	1,072		1,794	26,298	3,166	31,258	5,711	153,982
11		2,400	2,400	391	156,837	1,072		1,794	26,298	3,166	31,258	5,099	159,081
12		2,400	2,400	350	157,186	1,072		1,794	26,298	3,166	31,258	4,553	163,634
13		2,400	2,400	312	157,498	1,072		1,794	26,298	3,166	31,258	4,065	167,698
14		2,400	2,400	279	157,777	1,072		1,794	26,298	3,166	31,258	3,629	171,327
15		2,400	2,400	249	158,026	1,072		1,794	26,298	3,166	31,258	3,240	174,568
16		2,400	2,400	222	158,248	1,072		1,794	26,298	3,166	31,258	2,893	177,461
17		2,400	2,400	198	158,446	1,072		1,794	26,298	3,166	31,258	2,583	180,044
18		2,400	2,400	177	158,623	1,072		1,794	26,298	3,166	31,258	2,306	182,351
19		2,400	2,400	158	158,781	1,072		1,794	26,298	3,166	31,258	2,059	184,410
20		2,400	2,400	141	158,922	1,072		1,794	26,298	3,166	31,258	1,839	186,249
21		2,400	2,400	126	159,049	1,072		1,794	26,298	3,166	31,258	1,642	187,890
22		2,400	2,400	113	159,161	1,072		1,794	26,298	3,166	31,258	1,466	189,356
23		2,400	2,400	100	159,262	1,072		1,794	26,298	3,166	31,258	1,309	190,665
24		2,400	2,400	90	159,351	1,072		1,794	26,298	3,166	31,258	1,169	191,833
25		2,400	2,400	80	159,431	1,072		1,794	26,298	3,166	31,258	1,043	192,877
26		2,400	2,400	72	159,503	1,072		1,794	26,298	3,166	31,258	932	193,808
27		2,400	2,400	64	159,567	1,072	4,663	1,794	26,298	3,166	35,921	956	194,764
28		2,400	2,400	57	159,624	1,072	23,317	1,794	26,298	3,166	54,575	1,297	196,061
29		2,400	2,400	51	159,675	1,072	41,971	1,794	26,298	3,166	73,229	1,553	197,614
30	23,070	2,400	25,470	482	160,157	1,072	23,317	1,794	26,298	3,166	54,575	1,034	198,648
31		2,400	2,400	41	160,198	1,072		1,794	26,298	3,166	31,258	529	199,176
32		2,400	2,400	36	160,234	1,072		1,794	26,298	3,166	31,258	472	199,648
33		2,400	2,400	32	160,266	1,072		1,794	26,298	3,166	31,258	421	200,070
34		2,400	2,400	29	160,295	1,072		1,794	26,298	3,166	31,258	376	200,446
35		2,400	2,400	26	160,321	1,072		1,794	26,298	3,166	31,258	336	200,782
36		2,400	2,400	23	160,344	1,072		1,794	26,298	3,166	31,258	300	201,082
37		2,400	2,400	21	160,365	1,072		1,794	26,298	3,166	31,258	268	201,349
38		2,400	2,400	18	160,383	1,072		1,794	26,298	3,166	31,258	239	201,589
39		2,400	2,400	16	160,399	1,072		1,794	26,298	3,166	31,258	213	201,802
40		2,400	2,400	15	160,414	1,072		1,794	26,298	3,166	31,258	191	201,993
41		2,400	2,400	13	160,427	1,072		1,794	26,298	3,166	31,258	170	202,163
42		2,400	2,400	12	160,439	1,072		1,794	26,298	3,166	31,258	152	202,315
43		2,400	2,400	10	160,449	1,072		1,794	26,298	3,166	31,258	136	202,450
44		2,400	2,400	9	160,458	1,072		1,794	26,298	3,166	31,258	121	202,572
45		2,400	2,400	8	160,467	1,072		1,794	26,298	3,166	31,258	108	202,680
46		2,400	2,400	7	160,474	1,072		1,794	26,298	3,166	31,258	97	202,776
47		2,400	2,400	7	160,481	1,072		1,794	26,298	3,166	31,258	86	202,863
48		2,400	2,400	6	160,487	1,072		1,794	26,298	3,166	31,258	77	202,940
49		2,400	2,400	5	160,492	1,072		1,794	26,298	3,166	31,258	69	203,008
50		2,400	2,400	5	160,497	1,072	(31,090)	1,794	26,298	3,166	168	0	203,009

Cumulative Present Worth of Hydropower Costs:	160,497
Cumulative Present Worth of Thermal Costs:	203,009
Benefit-Cost Ratio @ 12%:	1.26
Equalizing Discount Rate:	16.3%

PROJECT NAME: KAMBARATA 2 PEAKING

				Construction Cost	HYDRO	CCGT
Installed Capacity (MW)	360.0	Thermal Capacity Cost($/kW)	750			
Dependable Capacity (MW)	210.0	Fixed O&M Cost ($/kW-yr)	15	YEAR 1	30%	
Hydro Mechanical Availability	1.087	Variable O&M Cost ($/MWh)	3.5	YEAR 2	50%	50%
Energy Generation (GWh)	1148.0	Energy Value ($/MWh)	30	YEAR 3	20%	50%
Construction Cost ($*1000)	260,700					
O&M Cost ($/kW/year)	10.0	Discount Rate	12.0%	TOTAL	100%	100%

	HYDROPOWER COSTS					THERMAL COSTS							
YEAR	Const. Cost	O&M Cost	Total Cost	Present Worth	Cum. Present Worth	Energy Gen.	Thermal Const. Cost	Fixed O&M Cost	Energy Cost	Variable O&M Cost	Total Cost	Present Worth	Cum. Present Worth
	78,210		78,210	55,668	55,668						0	0	0
	130,350		130,350	82,840	138,508		85,601				85,601	54,401	54,401
	52,140		52,140	29,586	168,094		85,601				85,601	48,572	102,974
1		3,600	3,600	1,824	169,918	1,148		3,424	34,440	4,018	41,882	21,219	124,192
2		3,600	3,600	1,628	171,546	1,148		3,424	34,440	4,018	41,882	18,945	143,138
3		3,600	3,600	1,454	173,000	1,148		3,424	34,440	4,018	41,882	16,915	160,053
4		3,600	3,600	1,298	174,298	1,148		3,424	34,440	4,018	41,882	15,103	175,156
5		3,600	3,600	1,159	175,457	1,148		3,424	34,440	4,018	41,882	13,485	188,641
6		3,600	3,600	1,035	176,492	1,148		3,424	34,440	4,018	41,882	12,040	200,681
7		3,600	3,600	924	177,416	1,148		3,424	34,440	4,018	41,882	10,750	211,431
8		3,600	3,600	825	178,241	1,148		3,424	34,440	4,018	41,882	9,598	221,030
9		3,600	3,600	737	178,978	1,148		3,424	34,440	4,018	41,882	8,570	229,599
10		3,600	3,600	658	179,636	1,148		3,424	34,440	4,018	41,882	7,652	237,251
11		3,600	3,600	587	180,223	1,148		3,424	34,440	4,018	41,882	6,832	244,083
12		3,600	3,600	524	180,747	1,148		3,424	34,440	4,018	41,882	6,100	250,183
13		3,600	3,600	468	181,215	1,148		3,424	34,440	4,018	41,882	5,446	255,629
14		3,600	3,600	418	181,633	1,148		3,424	34,440	4,018	41,882	4,863	260,492
15		3,600	3,600	373	182,007	1,148		3,424	34,440	4,018	41,882	4,342	264,834
16		3,600	3,600	333	182,340	1,148		3,424	34,440	4,018	41,882	3,877	268,710
17		3,600	3,600	298	182,637	1,148		3,424	34,440	4,018	41,882	3,461	272,172
18		3,600	3,600	266	182,903	1,148		3,424	34,440	4,018	41,882	3,090	275,262
19		3,600	3,600	237	183,140	1,148	85,601	3,424	34,440	4,018	127,483	8,399	283,661
20		3,600	3,600	212	183,352	1,148	85,601	3,424	34,440	4,018	127,483	7,499	291,160
21		3,600	3,600	189	183,541	1,148		3,424	34,440	4,018	41,882	2,200	293,360
22		3,600	3,600	169	183,710	1,148		3,424	34,440	4,018	41,882	1,964	295,324
23		3,600	3,600	151	183,860	1,148		3,424	34,440	4,018	41,882	1,754	297,077
24		3,600	3,600	135	183,995	1,148		3,424	34,440	4,018	41,882	1,566	298,643
25		3,600	3,600	120	184,115	1,148		3,424	34,440	4,018	41,882	1,398	300,041
26		3,600	3,600	107	184,223	1,148		3,424	34,440	4,018	41,882	1,248	301,289
27		3,600	3,600	96	184,318	1,148		3,424	34,440	4,018	41,882	1,114	302,403
28		3,600	3,600	86	184,404	1,148		3,424	34,440	4,018	41,882	995	303,398
29		3,600	3,600	76	184,480	1,148		3,424	34,440	4,018	41,882	888	304,287
30	26,070	3,600	29,670	562	185,042	1,148		3,424	34,440	4,018	41,882	793	305,080
31		3,600	3,600	61	185,103	1,148		3,424	34,440	4,018	41,882	708	305,788
32		3,600	3,600	54	185,157	1,148		3,424	34,440	4,018	41,882	632	306,421
33		3,600	3,600	49	185,206	1,148		3,424	34,440	4,018	41,882	565	306,985
34		3,600	3,600	43	185,249	1,148		3,424	34,440	4,018	41,882	504	307,489
35		3,600	3,600	39	185,288	1,148		3,424	34,440	4,018	41,882	450	307,939
36		3,600	3,600	35	185,322	1,148		3,424	34,440	4,018	41,882	402	308,341
37		3,600	3,600	31	185,353	1,148		3,424	34,440	4,018	41,882	359	308,700
38		3,600	3,600	28	185,381	1,148		3,424	34,440	4,018	41,882	320	309,020
39		3,600	3,600	25	185,405	1,148	85,601	3,424	34,440	4,018	127,483	871	309,891
40		3,600	3,600	22	185,427	1,148	85,601	3,424	34,440	4,018	127,483	777	310,669
41		3,600	3,600	20	185,447	1,148		3,424	34,440	4,018	41,882	228	310,897
42		3,600	3,600	18	185,464	1,148		3,424	34,440	4,018	41,882	204	311,100
43		3,600	3,600	16	185,480	1,148		3,424	34,440	4,018	41,882	182	311,282
44		3,600	3,600	14	185,494	1,148		3,424	34,440	4,018	41,882	162	311,444
45		3,600	3,600	12	185,507	1,148		3,424	34,440	4,018	41,882	145	311,589
46		3,600	3,600	11	185,518	1,148		3,424	34,440	4,018	41,882	129	311,719
47		3,600	3,600	10	185,528	1,148		3,424	34,440	4,018	41,882	116	311,834
48		3,600	3,600	9	185,536	1,148		3,424	34,440	4,018	41,882	103	311,937
49		3,600	3,600	8	185,544	1,148		3,424	34,440	4,018	41,882	92	312,029
50		3,600	3,600	7	185,551	1,148	(85,601)	3,424	34,440	4,018	(43,719)	(86)	311,944

Cumulative Present Worth of Hydropower Costs:	185,551
Cumulative Present Worth of Thermal Costs:	311,944
Benefit-Cost Ratio @ 12%:	1.68
Equalizing Discount Rate:	26.2%

PROJECT NAME: KAMBARATA 1

Installed Capacity (MW)	1900.0	Thermal Capacity Cost($/kW)	750
Dependable Capacity (MW)	1300.0	Fixed O&M Cost ($/kW-yr)	15
Hydro Mechanical Availability	1.087	Variable O&M Cost ($/MWh)	3.5
Energy Generation (GWh)	5164.0	Energy Value ($/MWh)	30
Construction Cost ($*1000)	1,675,400		
O&M Cost ($/kW/year)	10.0	Discount Rate	12.0%

Construction Cost	HYDRO	CCGT
YEAR 1	5%	
YEAR 2	5%	
YEAR 3	10%	
YEAR 4	15%	
YEAR 5	20%	
YEAR 6	20%	50%
YEAR 7	20%	50%
YEAR 8	5%	
TOTAL	100%	100%

	HYDROPOWER COSTS					THERMAL COSTS							
YEAR	Const. Cost	O&M Cost	Total Cost	Present Worth	Cum. Present Worth	Energy Gen.	Thermal Const. Cost	Fixed O&M Cost	Energy Cost	Variable O&M Cost	Total Cost	Present Worth	Cum. Present Worth
	83,770		83,770	59,626	59,626		0				0	0	0
	83,770		83,770	53,237	112,863		0				0	0	0
	167,540		167,540	95,067	207,930		0				0	0	0
	251,310		251,310	127,321	335,251		0				0	0	0
	335,080		335,080	151,573	486,825		0				0	0	0
	335,080		335,080	135,333	622,158		529,913				529,913	214,023	214,023
	335,080		335,080	120,833	742,991		529,913				529,913	191,092	405,115
1	83,770		83,770	26,972	769,963	5,164		21,197	154,920	16,074	194,191	62,524	467,639
2		19,000	19,000	5,462	775,425	5,164		21,197	154,920	18,074	194,191	55,825	523,464
3		19,000	19,000	4,877	780,301	5,164		21,197	154,920	18,074	194,191	49,844	573,308
4		19,000	19,000	4,354	784,656	5,164		21,197	154,920	18,074	194,191	44,503	617,811
5		19,000	19,000	3,888	788,544	5,164		21,197	154,920	18,074	194,191	39,735	657,546
6		19,000	19,000	3,471	792,015	5,164		21,197	154,920	18,074	194,191	35,478	693,024
7		19,000	19,000	3,099	795,114	5,164		21,197	154,920	18,074	194,191	31,677	724,701
8		19,000	19,000	2,767	797,881	5,164		21,197	154,920	18,074	194,191	28,283	752,984
9		19,000	19,000	2,471	800,352	5,164		21,197	154,920	18,074	194,191	25,252	778,236
10		19,000	19,000	2,205	802,558	5,164		21,197	154,920	18,074	194,191	22,547	800,783
11		19,000	19,000	1,970	804,528	5,164		21,197	154,920	18,074	194,191	20,131	820,914
12		19,000	19,000	1,759	806,286	5,164		21,197	154,920	18,074	194,191	17,974	838,888
13		19,000	19,000	1,570	807,857	5,164		21,197	154,920	18,074	194,191	16,048	854,937
14		19,000	19,000	1,402	809,259	5,164		21,197	154,920	18,074	194,191	14,329	869,266
15		19,000	19,000	1,252	810,510	5,164		21,197	154,920	18,074	194,191	12,794	882,059
16		19,000	19,000	1,118	811,628	5,164		21,197	154,920	18,074	194,191	11,423	893,482
17		19,000	19,000	998	812,626	5,164		21,197	154,920	18,074	194,191	10,199	903,681
18		19,000	19,000	891	813,517	5,164		21,197	154,920	18,074	194,191	9,106	912,787
19		19,000	19,000	796	814,312	5,164	529,913	21,197	154,920	18,074	724,103	30,318	943,105
20		19,000	19,000	710	815,023	5,164	529,913	21,197	154,920	18,074	724,103	27,069	970,174
21		19,000	19,000	634	815,657	5,164		21,197	154,920	18,074	194,191	6,482	976,656
22		19,000	19,000	566	816,223	5,164		21,197	154,920	18,074	194,191	5,787	982,443
23		19,000	19,000	506	816,729	5,164		21,197	154,920	18,074	194,191	5,167	987,611
24		19,000	19,000	451	817,180	5,164		21,197	154,920	18,074	194,191	4,614	992,224
25		19,000	19,000	403	817,583	5,164		21,197	154,920	18,074	194,191	4,119	996,343
26		19,000	19,000	360	817,943	5,164		21,197	154,920	18,074	194,191	3,678	1,000,021
27		19,000	19,000	321	818,264	5,164		21,197	154,920	18,074	194,191	3,284	1,003,305
28		19,000	19,000	287	818,551	5,164		21,197	154,920	18,074	194,191	2,932	1,006,237
29		19,000	19,000	256	818,807	5,164		21,197	154,920	18,074	194,191	2,618	1,008,855
30	167,540	19,000	186,540	2,245	821,053	5,164		21,197	154,920	18,074	194,191	2,337	1,011,192
31		19,000	19,000	204	821,257	5,164		21,197	154,920	18,074	194,191	2,087	1,013,279
32		19,000	19,000	182	821,439	5,164		21,197	154,920	18,074	194,191	1,863	1,015,142
33		19,000	19,000	163	821,602	5,164		21,197	154,920	18,074	194,191	1,664	1,016,806
34		19,000	19,000	145	821,747	5,164		21,197	154,920	18,074	194,191	1,485	1,018,292
35		19,000	19,000	130	821,877	5,164		21,197	154,920	18,074	194,191	1,326	1,019,618
36		19,000	19,000	116	821,993	5,164		21,197	154,920	18,074	194,191	1,184	1,020,802
37		19,000	19,000	103	822,096	5,164		21,197	154,920	18,074	194,191	1,057	1,021,859
38		19,000	19,000	92	822,188	5,164		21,197	154,920	18,074	194,191	944	1,022,803
39		19,000	19,000	82	822,271	5,164	529,913	21,197	154,920	18,074	724,103	3,143	1,025,946
40		19,000	19,000	74	822,345	5,164	529,913	21,197	154,920	18,074	724,103	2,806	1,028,752
41		19,000	19,000	66	822,410	5,164		21,197	154,920	18,074	194,191	672	1,029,424
42		19,000	19,000	59	822,469	5,164		21,197	154,920	18,074	194,191	600	1,030,024
43		19,000	19,000	52	822,522	5,164		21,197	154,920	18,074	194,191	536	1,030,560
44		19,000	19,000	47	822,568	5,164		21,197	154,920	18,074	194,191	478	1,031,038
45		19,000	19,000	42	822,610	5,164		21,197	154,920	18,074	194,191	427	1,031,465
46		19,000	19,000	37	822,647	5,164		21,197	154,920	18,074	194,191	381	1,031,847
47		19,000	19,000	33	822,681	5,164		21,197	154,920	18,074	194,191	340	1,032,187
48		19,000	19,000	30	822,710	5,164		21,197	154,920	18,074	194,191	304	1,032,491
49		19,000	19,000	27	822,737	5,164		21,197	154,920	18,074	194,191	271	1,032,762
50		19,000	19,000	24	822,761	5,164	(529,913)	21,197	154,920	18,074	(335,722)	(419)	1,032,343

Cumulative Present Worth of Hydropower Costs:	822,761
Cumulative Present Worth of Thermal Costs:	1,032,343
Benefit-Cost Ratio @ 12 %:	1.25
Equalizing Discount Rate:	15.9%

PROJECT NAME: KAMBARATA 1 ARCH DAM ALTERNATIVE

Installed Capacity (MW)	1700.0	Thermal Capacity Cost($/kW)	750
Dependable Capacity (MW)	1300.0	Fixed O&M Cost ($/kW-yr)	15
Hydro Mechanical Availability	1.087	Variable O&M Cost ($/MWh)	3.5
Energy Generation (GWh)	4611.0	Energy Value ($/MWh)	30
Construction Cost ($*1000)	1,850,000		
O&M Cost ($/kW/year)	10.0	Discount Rate	12.0%

Construction Cost	HYDRO	COOT
YEAR 1	5%	
YEAR 2	5%	
YEAR 3	10%	
YEAR 4	15%	
YEAR 5	20%	
YEAR 6	20%	50%
YEAR 7	20%	50%
YEAR 8	5%	
TOTAL	100%	100%

	HYDROPOWER COSTS					THERMAL COSTS							
YEAR	Const. Cost	O&M Cost	Total Cost	Present Worth	Cum. Present Worth	Energy Gen.	Thermal Const. Cost	Fixed O&M Cost	Variable Energy Cost	Variable O&M Cost	Total Cost	Present Worth	Cum. Present Worth
	92,500		92,500	65,840	65,840		0				0	0	0
	92,500		92,500	58,785	124,625		0				0	0	0
	185,000		185,000	104,974	229,599		0				0	0	0
	277,500		277,500	140,590	370,189		0				0	0	0
	370,000		370,000	167,369	537,558		0				0	0	0
	370,000		370,000	149,437	686,995		529,913				529,913	214,023	214,023
	370,000		370,000	133,426	820,421		529,913				529,913	191,092	405,115
1	92,500		92,500	29,783	850,203	4,611		21,197	138,330	16,139	175,665	56,559	461,674
2		17,000	17,000	4,887	855,091	4,611		21,197	138,330	16,139	175,665	50,499	512,173
3		17,000	17,000	4,363	859,454	4,611		21,197	138,330	16,139	175,665	45,089	557,262
4		17,000	17,000	3,896	863,350	4,611		21,197	138,330	16,139	175,665	40,258	597,520
5		17,000	17,000	3,479	866,829	4,611		21,197	138,330	16,139	175,665	35,945	633,465
6		17,000	17,000	3,106	869,934	4,611		21,197	138,330	16,139	175,665	32,093	665,558
7		17,000	17,000	2,773	872,707	4,611		21,197	138,330	16,139	175,665	28,655	694,213
8		17,000	17,000	2,476	875,183	4,611		21,197	138,330	16,139	175,665	25,585	719,797
9		17,000	17,000	2,211	877,394	4,611		21,197	138,330	16,139	175,665	22,843	742,641
10		17,000	17,000	1,974	879,368	4,611		21,197	138,330	16,139	175,665	20,396	763,037
11		17,000	17,000	1,762	881,130	4,611		21,197	138,330	16,139	175,665	18,211	781,247
12		17,000	17,000	1,574	882,704	4,611		21,197	138,330	16,139	175,665	16,259	797,507
13		17,000	17,000	1,405	884,109	4,611		21,197	138,330	16,139	175,665	14,517	812,024
14		17,000	17,000	1,254	885,363	4,611		21,197	138,330	16,139	175,665	12,962	824,986
15		17,000	17,000	1,120	886,483	4,611		21,197	138,330	16,139	175,665	11,573	836,559
16		17,000	17,000	1,000	887,483	4,611		21,197	138,330	16,139	175,665	10,333	846,893
17		17,000	17,000	893	888,376	4,611		21,197	138,330	16,139	175,665	9,226	856,119
18		17,000	17,000	797	889,173	4,611		21,197	138,330	16,139	175,665	8,238	864,356
19		17,000	17,000	712	889,885	4,611	529,913	21,197	138,330	16,139	705,578	29,542	893,898
20		17,000	17,000	636	890,520	4,611	529,913	21,197	138,330	16,139	705,578	26,377	920,275
21		17,000	17,000	567	891,088	4,611		21,197	138,330	16,139	175,665	5,863	926,138
22		17,000	17,000	507	891,594	4,611		21,197	138,330	16,139	175,665	5,235	931,373
23		17,000	17,000	452	892,047	4,611		21,197	138,330	16,139	175,665	4,674	936,048
24		17,000	17,000	404	892,451	4,611		21,197	138,330	16,139	175,665	4,173	940,221
25		17,000	17,000	361	892,811	4,611		21,197	138,330	16,139	175,665	3,726	943,947
26		17,000	17,000	322	893,133	4,611		21,197	138,330	16,139	175,665	3,327	947,274
27		17,000	17,000	287	893,421	4,611		21,197	138,330	16,139	175,665	2,971	950,245
28		17,000	17,000	257	893,677	4,611		21,197	138,330	16,139	175,665	2,652	952,897
29		17,000	17,000	229	893,907	4,611		21,197	138,330	16,139	175,665	2,368	955,265
30	185,000	17,000	202,000	2,431	896,338	4,611		21,197	138,330	16,139	175,665	2,114	957,380
31		17,000	17,000	183	896,521	4,611		21,197	138,330	16,139	175,665	1,888	959,267
32		17,000	17,000	163	896,684	4,611		21,197	138,330	16,139	175,665	1,686	960,953
33		17,000	17,000	146	896,829	4,611		21,197	138,330	16,139	175,665	1,505	962,458
34		17,000	17,000	130	896,959	4,611		21,197	138,330	16,139	175,665	1,344	963,802
35		17,000	17,000	116	897,075	4,611		21,197	138,330	16,139	175,665	1,200	965,001
36		17,000	17,000	104	897,179	4,611		21,197	138,330	16,139	175,665	1,071	966,073
37		17,000	17,000	93	897,272	4,611		21,197	138,330	16,139	175,665	956	967,029
38		17,000	17,000	83	897,354	4,611		21,197	138,330	16,139	175,665	854	967,883
39		17,000	17,000	74	897,428	4,611	529,913	21,197	138,330	16,139	705,578	3,063	970,946
40		17,000	17,000	66	897,494	4,611	529,913	21,197	138,330	16,139	705,578	2,734	973,680
41		17,000	17,000	59	897,553	4,611		21,197	138,330	16,139	175,665	608	974,288
42		17,000	17,000	53	897,605	4,611		21,197	138,330	16,139	175,665	543	974,831
43		17,000	17,000	47	897,652	4,611		21,197	138,330	16,139	175,665	485	975,315
44		17,000	17,000	42	897,694	4,611		21,197	138,330	16,139	175,665	433	975,748
45		17,000	17,000	37	897,732	4,611		21,197	138,330	16,139	175,665	386	976,134
46		17,000	17,000	33	897,765	4,611		21,197	138,330	16,139	175,665	345	976,479
47		17,000	17,000	30	897,795	4,611		21,197	138,330	16,139	175,665	308	976,787
48		17,000	17,000	27	897,821	4,611		21,197	138,330	16,139	175,665	275	977,062
49		17,000	17,000	24	897,845	4,611		21,197	138,330	16,139	175,665	245	977,307
50		17,000	17,000	21	897,866	4,611	(529,913)	21,197	138,330	16,139	(354,248)	(442)	976,865

Cumulative Present Worth of Hydropower Costs: 897,866
Cumulative Present Worth of Thermal Costs: 976,865

Benefit-Cost Ratio @ 12 %: 1.09
Equalizing Discount Rate: 13.4%

EXHIBIT 8-26

PROJECT NAME: KIROV

Installed Capacity (MW)	21.0	Thermal Capacity Cost($/kW)	1600	Construction Cost	HYDRO	COAL
Dependable Capacity (MW)	3.0	Fixed O&M Cost ($/kW-yr)	30.0	YEAR 1	20%	5%
Hydro Mechanical Availability	1.237	Variable O&M Cost ($/MWh)	3.0	YEAR 2	25%	25%
Energy Generation (GWh)	70.0	Energy Value ($/MWh)	25.0	YEAR 3	35%	45%
Construction Cost ($*1000)	19,400			YEAR 4	20%	25%
O&M Cost ($/kW/year)	10.0	Discount Rate	12.0%	TOTAL	100%	100%

	HYDROPOWER COSTS					THERMAL COSTS							
YEAR	Const. Cost	O&M Cost	Total Cost	Present Worth	Cum. Present Worth	Energy Gen.	Thermal Const. Cost	Fixed O&M Cost	Variable Energy Cost	Variable O&M Cost	Total Cost	Present Worth	Cum. Present Worth
	3,880		3,880	2,762	2,762		297				297	211	211
	4,850		4,850	3,082	5,844		1,484				1,484	943	1,155
	6,790		6,790	3,853	9,697		2,672				2,672	1,516	2,671
	3,880		3,880	1,966	11,663		1,484				1,484	752	3,423
1		210	210	95	11,758	70		111	1,750	210	2,071	937	4,360
2		210	210	85	11,842	70		111	1,750	210	2,071	837	5,196
3		210	210	76	11,918	70		111	1,750	210	2,071	747	5,943
4		210	210	68	11,986	70		111	1,750	210	2,071	667	6,610
5		210	210	60	12,046	70		111	1,750	210	2,071	595	7,206
6		210	210	54	12,100	70		111	1,750	210	2,071	532	7,737
7		210	210	48	12,148	70		111	1,750	210	2,071	475	8,212
8		210	210	43	12,191	70		111	1,750	210	2,071	424	8,636
9		210	210	38	12,229	70		111	1,750	210	2,071	378	9,014
10		210	210	34	12,264	70		111	1,750	210	2,071	338	9,352
11		210	210	31	12,294	70		111	1,750	210	2,071	302	9,654
12		210	210	27	12,322	70		111	1,750	210	2,071	269	9,923
13		210	210	24	12,346	70		111	1,750	210	2,071	240	10,164
14		210	210	22	12,368	70		111	1,750	210	2,071	215	10,378
15		210	210	19	12,387	70		111	1,750	210	2,071	192	10,570
16		210	210	17	12,405	70		111	1,750	210	2,071	171	10,741
17		210	210	15	12,420	70		111	1,750	210	2,071	153	10,894
18		210	210	14	12,434	70		111	1,750	210	2,071	136	11,031
19		210	210	12	12,446	70		111	1,750	210	2,071	122	11,152
20		210	210	11	12,457	70		111	1,750	210	2,071	109	11,261
21		210	210	10	12,467	70		111	1,750	210	2,071	97	11,358
22		210	210	9	12,476	70		111	1,750	210	2,071	87	11,445
23		210	210	8	12,484	70		111	1,750	210	2,071	77	11,523
24		210	210	7	12,491	70		111	1,750	210	2,071	69	11,592
25		210	210	6	12,497	70		111	1,750	210	2,071	62	11,653
26		210	210	6	12,503	70		111	1,750	210	2,071	55	11,709
27		210	210	5	12,508	70	297	111	1,750	210	2,368	56	11,765
28		210	210	4	12,512	70	1,484	111	1,750	210	3,556	75	11,840
29		210	210	4	12,516	70	2,672	111	1,750	210	4,743	90	11,930
30	1,940	210	2,150	36	12,552	70	1,484	111	1,750	210	3,556	60	11,990
31		210	210	3	12,556	70		111	1,750	210	2,071	31	12,021
32		210	210	3	12,558	70		111	1,750	210	2,071	28	12,049
33		210	210	3	12,561	70		111	1,750	210	2,071	25	12,074
34		210	210	2	12,563	70		111	1,750	210	2,071	22	12,097
35		210	210	2	12,565	70		111	1,750	210	2,071	20	12,116
36		210	210	2	12,567	70		111	1,750	210	2,071	18	12,134
37		210	210	2	12,569	70		111	1,750	210	2,071	16	12,150
38		210	210	1	12,570	70		111	1,750	210	2,071	14	12,164
39		210	210	1	12,571	70		111	1,750	210	2,071	13	12,177
40		210	210	1	12,572	70		111	1,750	210	2,071	11	12,188
41		210	210	1	12,573	70		111	1,750	210	2,071	10	12,198
42		210	210	1	12,574	70		111	1,750	210	2,071	9	12,207
43		210	210	1	12,575	70		111	1,750	210	2,071	8	12,215
44		210	210	1	12,576	70		111	1,750	210	2,071	7	12,222
45		210	210	1	12,577	70		111	1,750	210	2,071	6	12,229
46		210	210	1	12,577	70		111	1,750	210	2,071	6	12,234
47		210	210	1	12,578	70		111	1,750	210	2,071	5	12,240
48		210	210	0	12,578	70		111	1,750	210	2,071	5	12,244
49		210	210	0	12,579	70		111	1,750	210	2,071	4	12,248
50		210	210	0	12,578	70	(1,979)	111	1,750	210	92	0	12,244

Cumulative Present Worth of Hydropower Costs:	12,578
Cumulative Present Worth of Thermal Costs:	12,244
Benefit-Cost Ratio @ 12%:	0.97
Equalizing Discount Rate:	11.6%

EXHIBIT 8-27

PROJECT NAME: ORUKTAM 1

Installed Capacity (MW)	60.0	Coal Capacity Cost(\$/kW)	1600	Construction Cost	HYDRO	COAL
Dependable Capacity (MW)	40.0	Coal Fixed O&M Cost (\$/kW-yr)	30.0	YEAR 1	15%	5%
Hydro Mechanical Availability	1.237	Variable Coal O&M Cost (\$/MWh)	3.0	YEAR 2	30%	25%
Hydro Energy Generation (GWh)	254	Variable GT O&M Cost (\$/MWh)	5.0	YEAR 3	35%	45%
Construction Cost (\$*1000)	160,000	Coal Energy Value (\$/MWh)	25.0	YEAR 4	20%	25%
O&M Cost (\$/kW/year)	10.0	GT Energy Value (\$/MWh)	60.0	TOTAL	100%	100%
		Coal Energy Generation (GWh)	254			
Discount Rate	12.0%	GT Energy Generation (GWh)	0			

	HYDROPOWER COSTS					THERMAL COSTS							
YEAR	Const. Cost	O&M Cost	Total Cost	Present Worth	Cum. Present Worth	Energy Gen.	Thermal Const. Cost	Fixed O&M Cost	Energy Cost	Variable O&M Cost	Total Cost	Present Worth	Cum. Present Worth
	27,000		27,000	19,218	19,218		3,958				3,958	2,818	2,818
	54,000		54,000	34,318	53,536		19,792				19,792	12,578	15,396
	63,000		63,000	35,748	89,284		35,626				35,625	20,215	35,611
	36,000		36,000	18,239	107,523		19,792				19,792	10,027	45,638
1		600	600	271	107,794	254		1,484	6,350	762	8,596	3,889	49,526
2		600	600	242	108,036	254		1,484	6,350	762	8,596	3,472	52,998
3		600	600	216	108,253	254		1,484	6,350	762	8,596	3,100	56,098
4		600	600	193	108,446	254		1,484	6,350	762	8,596	2,768	58,866
5		600	600	172	108,618	254		1,484	6,350	762	8,596	2,471	61,337
6		600	600	154	108,772	254		1,484	6,350	762	8,596	2,206	63,544
7		600	600	138	108,910	254		1,484	6,350	762	8,596	1,970	65,514
8		600	600	123	109,033	254		1,484	6,350	762	8,596	1,759	67,273
9		600	600	110	109,142	254		1,484	6,350	762	8,596	1,571	68,843
10		600	600	98	109,240	254		1,484	6,350	762	8,596	1,402	70,246
11		600	600	87	109,328	254		1,484	6,350	762	8,596	1,252	71,498
12		600	600	78	109,406	254		1,484	6,350	762	8,596	1,118	72,616
13		600	600	70	109,475	254		1,484	6,350	762	8,596	998	73,614
14		600	600	62	109,537	254		1,484	6,350	762	8,596	891	74,505
15		600	600	56	109,593	254		1,484	6,350	762	8,596	796	75,301
16		600	600	50	109,643	254		1,484	6,350	762	8,596	710	76,011
17		600	600	44	109,687	254		1,484	6,350	762	8,596	634	76,645
18		600	600	40	109,726	254		1,484	6,350	762	8,596	566	77,212
19		600	600	35	109,762	254		1,484	6,350	762	8,596	506	77,717
20		600	600	32	109,793	254		1,484	6,350	762	8,596	451	78,169
21		600	600	28	109,821	254		1,484	6,350	762	8,596	403	78,572
22		600	600	25	109,846	254		1,484	6,350	762	8,596	360	78,932
23		600	600	22	109,869	254		1,484	6,350	762	8,596	321	79,253
24		600	600	20	109,889	254		1,484	6,350	762	8,596	287	79,540
25		600	600	18	109,907	254		1,484	6,350	762	8,596	256	79,796
26		600	600	16	109,923	254		1,484	6,350	762	8,596	229	80,025
27		600	600	14	109,937	254	3,958	1,484	6,350	762	12,555	298	80,323
28		600	600	13	109,950	254	19,792	1,484	6,350	762	28,388	602	80,926
29		600	600	11	109,961	254	35,626	1,484	6,350	762	44,222	838	81,763
30	18,000	600	18,600	315	110,276	254	19,792	1,484	6,350	762	28,388	480	82,243
31		600	600	9	110,285	254		1,484	6,350	762	8,596	130	82,373
32		600	600	8	110,293	254		1,484	6,350	762	8,596	116	82,489
33		600	600	7	110,300	254		1,484	6,350	762	8,596	103	82,592
34		600	600	6	110,306	254		1,484	6,350	762	8,596	92	82,685
35		600	600	6	110,312	254		1,484	6,350	762	8,596	82	82,767
36		600	600	5	110,317	254		1,484	6,350	762	8,596	74	82,841
37		600	600	5	110,322	254		1,484	6,350	762	8,596	66	82,907
38		600	600	4	110,326	254		1,484	6,350	762	8,596	59	82,965
39		600	600	4	110,330	254		1,484	6,350	762	8,596	52	83,018
40		600	600	3	110,333	254		1,484	6,350	762	8,596	47	83,064
41		600	600	3	110,336	254		1,484	6,350	762	8,596	42	83,106
42		600	600	3	110,338	254		1,484	6,350	762	8,596	37	83,144
43		600	600	2	110,341	254		1,484	6,350	762	8,596	33	83,177
44		600	600	2	110,343	254		1,484	6,350	762	8,596	30	83,207
45		600	600	2	110,345	254		1,484	6,350	762	8,596	27	83,233
46		600	600	2	110,346	254		1,484	6,350	762	8,596	24	83,257
47		600	600	1	110,348	254		1,484	6,350	762	8,596	21	83,278
48		600	600	1	110,349	254		1,484	6,350	762	8,596	19	83,297
49		600	600	1	110,350	254		1,484	6,350	762	8,596	17	83,314
50		600	600	1	110,350	254	(26,389)	1,484	6,350	762	(17,793)	(35)	83,262

Cumulative Present Worth of Hydropower Costs:	110,350
Cumulative Present Worth of Thermal Costs:	83,262
Benefit-Cost Ratio @ 12%:	0.75
Equalizing Discount Rate:	7.3%

EXHIBIT 8-28

PROJECT NAME: ORUKTAM 2

Installed Capacity (MW)	48.0	Coal Capacity Cost($/kW)	1600	Construction Cost	HYDRO	COAL
Dependable Capacity (MW)	43.0	Coal Fixed O&M Cost ($/kW-yr)	30.0	YEAR 1	15%	5%
Hydro Mechanical Availability	1.237	Variable Coal O&M Cost ($/MWh)	3.0	YEAR 2	30%	25%
Hydro Energy Generation (GWh)	259	Variable GT O&M Cost ($/MWh)	5.0	YEAR 3	35%	45%
Construction Cost ($*1000)	180,000	Coal Energy Value ($/MWh)	25.0	YEAR 4	20%	25%
O&M Cost ($/kW/year)	10.0	GT Energy Value ($/MWh)	60.0	TOTAL	100%	100%
		Coal Energy Generation (GWh)	259			
Discount Rate	12.0%	GT Energy Generation (GWh)	0			

	HYDROPOWER COSTS					THERMAL COSTS							
YEAR	Const. Cost	O&M Cost	Total Cost	Present Worth	Cum. Present Worth	Energy Gen.	Thermal Const. Cost	Fixed O&M Cost	Energy Cost	Variable O&M Cost	Total Cost	Present Worth	Cum. Present Worth
	27,000		27,000	19,218	19,218		4,255				4,255	3,029	3,029
	54,000		54,000	34,318	53,536		21,276				21,276	13,522	16,550
	63,000		63,000	35,748	89,284		38,298				38,298	21,731	38,281
	36,000		36,000	18,239	107,523		21,276				21,276	10,779	49,061
1		480	480	217	107,740	259		1,596	6,475	777	8,848	4,002	53,063
2		480	480	194	107,934	259		1,596	6,475	777	8,848	3,573	56,636
3		480	480	173	108,107	259		1,596	6,475	777	8,848	3,191	59,827
4		480	480	155	108,261	259		1,596	6,475	777	8,848	2,849	62,676
5		480	480	138	108,399	259		1,596	6,475	777	8,848	2,544	65,219
6		480	480	123	108,522	259		1,596	6,475	777	8,848	2,271	67,490
7		480	480	110	108,632	259		1,596	6,475	777	8,848	2,028	69,518
8		480	480	98	108,731	259		1,596	6,475	777	8,848	1,810	71,328
9		480	480	88	108,818	259		1,596	6,475	777	8,848	1,616	72,945
10		480	480	78	108,897	259		1,596	6,475	777	8,848	1,443	74,388
11		480	480	70	108,967	259		1,596	6,475	777	8,848	1,289	75,677
12		480	480	62	109,029	259		1,596	6,475	777	8,848	1,151	76,827
13		480	480	56	109,085	259		1,596	6,475	777	8,848	1,027	77,854
14		480	480	50	109,135	259		1,596	6,475	777	8,848	917	78,772
15		480	480	44	109,179	259		1,596	6,475	777	8,848	819	79,591
16		480	480	40	109,219	259		1,596	6,475	777	8,848	731	80,322
17		480	480	35	109,254	259		1,596	6,475	777	8,848	653	80,975
18		480	480	32	109,286	259		1,596	6,475	777	8,848	583	81,558
19		480	480	28	109,314	259		1,596	6,475	777	8,848	520	82,078
20		480	480	25	109,339	259		1,596	6,475	777	8,848	465	82,543
21		480	480	23	109,362	259		1,596	6,475	777	8,848	415	82,958
22		480	480	20	109,382	259		1,596	6,475	777	8,848	370	83,328
23		480	480	18	109,400	259		1,596	6,475	777	8,848	331	83,659
24		480	480	16	109,416	259		1,596	6,475	777	8,848	295	83,954
25		480	480	14	109,430	259		1,596	6,475	777	8,848	264	84,218
26		480	480	13	109,443	259		1,596	6,475	777	8,848	235	84,453
27		480	480	11	109,454	259	4,255	1,596	6,475	777	13,103	311	84,765
28		480	480	10	109,464	259	21,276	1,596	6,475	777	30,124	639	85,404
29		480	480	9	109,473	259	38,298	1,596	6,475	777	47,145	893	86,296
30	18,000	480	18,480	313	109,786	259	21,276	1,596	6,475	777	30,124	509	86,806
31		480	480	7	109,793	259		1,596	6,475	777	8,848	134	86,939
32		480	480	6	109,800	259		1,596	6,475	777	8,848	119	87,059
33		480	480	6	109,805	259		1,596	6,475	777	8,848	106	87,165
34		480	480	5	109,811	259		1,596	6,475	777	8,848	95	87,260
35		480	480	5	109,815	259		1,596	6,475	777	8,848	85	87,345
36		480	480	4	109,819	259		1,596	6,475	777	8,848	76	87,421
37		480	480	4	109,823	259		1,596	6,475	777	8,848	68	87,489
38		480	480	3	109,826	259		1,596	6,475	777	8,848	60	87,549
39		480	480	3	109,829	259		1,596	6,475	777	8,848	54	87,603
40		480	480	3	109,832	259		1,596	6,475	777	8,848	48	87,651
41		480	480	2	109,834	259		1,596	6,475	777	8,848	43	87,694
42		480	480	2	109,836	259		1,596	6,475	777	8,848	38	87,733
43		480	480	2	109,838	259		1,596	6,475	777	8,848	34	87,767
44		480	480	2	109,840	259		1,596	6,475	777	8,848	31	87,798
45		480	480	2	109,841	259		1,596	6,475	777	8,848	27	87,825
46		480	480	1	109,843	259		1,596	6,475	777	8,848	24	87,849
47		480	480	1	109,844	259		1,596	6,475	777	8,848	22	87,871
48		480	480	1	109,845	259		1,596	6,475	777	8,848	19	87,891
49		480	480	1	109,846	259		1,596	6,475	777	8,848	17	87,908
50		480	480	1	109,846	259	(28,369)	1,596	6,475	777	(19,521)	(38)	87,852

Cumulative Present Worth of Hydropower Costs:	109,846
Cumulative Present Worth of Thermal Costs:	87,852
Benefit-Cost Ratio @ 12%:	0.80
Equalizing Discount Rate:	8.1%

EXHIBIT 8-29

PROJECT NAME: ECHINARYN

Installed Capacity (MW)	9.5	Coal Capacity Cost($/kW)	1600	Construction Cost	HYDRO	COAL
Dependable Capacity (MW)	8.4	Coal Fixed O&M Cost ($/kW-yr)	32.0	YEAR 1	25%	5%
Hydro Mechanical Availability	1.237	Variable Coal O&M Cost ($/MWh)	3.0	YEAR 2	50%	25%
Hydro Energy Generation (GWh)	50	Variable GT O&M Cost ($/MWh)	5.0	YEAR 3	25%	45%
Construction Cost ($*1000)	37,500	Coal Energy Value ($/MWh)	25.0	YEAR 4		25%
O&M Cost ($/kW/year)	10.0	GT Energy Value ($/MWh)	60.0	TOTAL	100%	100%
		Coal Energy Generation (GWh)	50			
Discount Rate	12.0%	GT Energy Generation (GWh)	0			

	HYDROPOWER COSTS					THERMAL COSTS							
YEAR	Const. Cost	O&M Cost	Total Cost	Present Worth	Cum. Present Worth	Energy Gen.	Thermal Const. Cost	Fixed O&M Cost	Variable Energy Cost	Variable O&M Cost	Total Cost	Present Worth	Cum. Present Worth
	9,375		9,375	6,673	6,673		831				831	592	592
	18,750		18,750	11,916	18,589		4,156				4,156	2,641	3,233
	9,375		9,375	5,320	23,909		7,481				7,481	4,245	7,478
1		95	95	48	23,957	50	4,156	312	1,243	149	5,860	2,969	10,447
2		95	95	43	24,000	50		312	1,243	149	1,703	770	11,217
3		95	95	38	24,038	50		312	1,243	149	1,703	688	11,905
4		95	95	34	24,072	50		312	1,243	149	1,703	614	12,520
5		95	95	31	24,103	50		312	1,243	149	1,703	548	13,068
6		95	95	27	24,130	50		312	1,243	149	1,703	490	13,558
7		95	95	24	24,155	50		312	1,243	149	1,703	437	13,995
8		95	95	22	24,176	50		312	1,243	149	1,703	390	14,385
9		95	95	19	24,196	50		312	1,243	149	1,703	349	14,734
10		95	95	17	24,213	50		312	1,243	149	1,703	311	15,045
11		95	95	15	24,229	50		312	1,243	149	1,703	278	15,323
12		95	95	14	24,242	50		312	1,243	149	1,703	248	15,571
13		95	95	12	24,255	50		312	1,243	149	1,703	221	15,792
14		95	95	11	24,266	50		312	1,243	149	1,703	198	15,990
15		95	95	10	24,276	50		312	1,243	149	1,703	177	16,167
16		95	95	9	24,284	50		312	1,243	149	1,703	158	16,324
17		95	95	8	24,292	50		312	1,243	149	1,703	141	16,465
18		95	95	7	24,299	50		312	1,243	149	1,703	126	16,591
19		95	95	6	24,306	50		312	1,243	149	1,703	112	16,703
20		95	95	6	24,311	50		312	1,243	149	1,703	100	16,803
21		95	95	5	24,316	50		312	1,243	149	1,703	89	16,893
22		95	95	4	24,371	50		312	1,243	149	1,703	80	16,973
23		95	95	4	24,315	50		312	1,243	149	1,703	71	17,044
24		95	95	4	24,328	50		312	1,243	149	1,703	64	17,108
25		95	95	3	24,331	50		312	1,243	149	1,703	57	17,164
26		95	95	3	24,334	50		312	1,243	149	1,703	51	17,215
27		95	95	3	24,337	50	831	312	1,243	149	2,535	67	17,283
28		95	95	2	24,339	50	4,156	312	1,243	149	5,860	139	17,422
29		95	95	2	24,341	50	7,481	312	1,243	149	9,185	195	17,617
30	3,750	95	3,845	73	24,414	50	4,156	312	1,243	149	5,860	111	17,728
31		95	95	2	24,415	50		312	1,243	149	1,703	29	17,756
32		95	95	1	24,417	50		312	1,243	149	1,703	26	17,782
33		95	95	1	24,418	50		312	1,243	149	1,703	23	17,805
34		95	95	1	24,419	50		312	1,243	149	1,703	21	17,826
35		95	95	1	24,420	50		312	1,243	149	1,703	18	17,844
36		95	95	1	24,421	50		312	1,243	149	1,703	16	17,860
37		95	95	1	24,422	50		312	1,243	149	1,703	15	17,875
38		95	95	1	24,423	50		312	1,243	149	1,703	13	17,888
39		95	95	1	24,423	50		312	1,243	149	1,703	12	17,900
40		95	95	1	24,424	50		312	1,243	149	1,703	10	17,910
41		95	95	1	24,424	50		312	1,243	149	1,703	9	17,919
42		95	95	0	24,425	50		312	1,243	149	1,703	8	17,927
43		95	95	0	24,425	50		312	1,243	149	1,703	7	17,935
44		95	95	0	24,426	50		312	1,243	149	1,703	7	17,941
45		95	95	0	24,426	50		312	1,243	149	1,703	6	17,947
46		95	95	0	24,426	50		312	1,243	149	1,703	5	17,953
47		95	95	0	24,427	50		312	1,243	149	1,703	5	17,957
48		95	95	0	24,427	50		312	1,243	149	1,703	4	17,962
49		95	95	0	24,427	50		312	1,243	149	1,703	4	17,965
50		95	95	0	24,427	50	(5,542)	312	1,243	149	(3,838)	(8)	17,958

Cumulative Present Worth of Hydropower Costs:	24,427
Cumulative Present Worth of Thermal Costs:	17,958
Benefit-Cost Ratio @ 12%:	0.74
Equalizing Discount Rate:	7.1%

EXHIBIT 8-30

PROJECT NAME: DZHANYKEL

Installed Capacity (MW)	130.0	Coal Capacity Cost ($/kW)	1600	Construction Cost	HYDRO	COAL
Dependable Capacity (MW)	48.0	Coal Fixed O&M Cost ($/kW-yr)	30.0	YEAR 1	10%	
Hydro Mechanical Availability	1.237	Variable Coal O&M Cost ($/MWh)	3.0	YEAR 2	20%	5%
Hydro Energy Generation (GWh)	470	Variable GT O&M Cost ($/MWh)	5.0	YEAR 3	30%	25%
Construction Cost ($*1000)	176,500	Coal Energy Value ($/MWh)	25.0	YEAR 4	25%	45%
O&M Cost ($/kW/year)	10.0	GT Energy Value ($/MWh)	60.0	YEAR 5	15%	25%
		Coal Energy Generation (GWh)	402	TOTAL	100%	100%
Discount Rate	12.0%	GT Energy Generation (GWh)	68			

	HYDROPOWER COSTS					THERMAL COSTS							
YEAR.	Const. Cost	O&M Cost	Total Cost	Present Worth	Cum. Present Worth	Energy Gen.	Thermal Const. Cost	Fixed O&M Cost	Energy Cost	Variable O&M Cost	Total Cost	Present Worth	Cum. Present Worth
	17,650		17,650	12,563	12,563		0				0	0	0
	35,300		35,300	22,434	34,997		4,750				4,750	3,019	3,019
	52,950		52,950	30,045	65,042		23,750				23,750	13,477	16,495
	44,125		44,125	22,355	87,397		42,751				42,751	21,659	38,154
	26,475		26,475	11,976	99,373		23,750				23,750	10,743	48,898
1		1,300	1,300	525	99,898	470		1,781	14,128	1,546	17,455	7,050	55,947
2		1,300	1,300	469	100,367	470		1,781	14,128	1,546	17,455	6,294	62,242
3		1,300	1,300	419	100,785	470		1,781	14,128	1,546	17,455	5,620	67,862
4		1,300	1,300	374	101,159	470		1,781	14,128	1,546	17,455	5,018	72,880
5		1,300	1,300	334	101,493	470		1,781	14,128	1,546	17,455	4,480	77,360
6		1,300	1,300	298	101,791	470		1,781	14,128	1,546	17,455	4,000	81,360
7		1,300	1,300	266	102,057	470		1,781	14,128	1,546	17,455	3,572	84,932
8		1,300	1,300	238	102,294	470		1,781	14,128	1,546	17,455	3,189	88,121
9		1,300	1,300	212	102,506	470		1,781	14,128	1,546	17,455	2,847	90,968
10		1,300	1,300	189	102,696	470		1,781	14,128	1,546	17,455	2,542	93,510
11		1,300	1,300	169	102,865	470		1,781	14,128	1,546	17,455	2,270	95,780
12		1,300	1,300	151	103,016	470		1,781	14,128	1,546	17,455	2,027	97,807
13		1,300	1,300	135	103,150	470		1,781	14,128	1,546	17,455	1,809	99,616
14		1,300	1,300	120	103,271	470		1,781	14,128	1,546	17,455	1,616	101,232
15		1,300	1,300	107	103,378	470		1,781	14,128	1,546	17,455	1,443	102,674
16		1,300	1,300	96	103,474	470		1,781	14,128	1,546	17,455	1,288	103,962
17		1,300	1,300	86	103,560	470		1,781	14,128	1,546	17,455	1,150	105,112
18		1,300	1,300	76	103,636	470		1,781	14,128	1,546	17,455	1,027	106,139
19		1,300	1,300	68	103,704	470		1,781	14,128	1,546	17,455	917	107,056
20		1,300	1,300	61	103,765	470		1,781	14,128	1,546	17,455	819	107,874
21		1,300	1,300	54	103,820	470		1,781	14,128	1,546	17,455	731	108,605
22		1,300	1,300	49	103,868	470		1,781	14,128	1,546	17,455	653	109,258
23		1,300	1,300	43	103,912	470		1,781	14,128	1,546	17,455	583	109,840
24		1,300	1,300	39	103,951	470		1,781	14,128	1,546	17,455	520	110,361
25		1,300	1,300	35	103,985	470		1,781	14,128	1,546	17,455	464	110,825
26		1,300	1,300	31	104,016	470		1,781	14,128	1,546	17,455	415	111,240
27		1,300	1,300	28	104,044	470	4,750	1,781	14,128	1,546	22,205	471	111,711
28		1,300	1,300	25	104,068	470	23,750	1,781	14,128	1,546	41,205	780	112,491
29		1,300	1,300	22	104,090	470	42,751	1,781	14,128	1,546	60,206	1,018	113,509
30	17,650	1,300	18,950	286	104,376	470	23,750	1,781	14,128	1,546	41,205	622	114,131
31		1,300	1,300	18	104,394	470		1,781	14,128	1,546	17,455	235	114,367
32		1,300	1,300	16	104,410	470		1,781	14,128	1,546	17,455	210	114,577
33		1,300	1,300	14	104,424	470		1,781	14,128	1,546	17,455	188	114,764
34		1,300	1,300	12	104,436	470		1,781	14,128	1,546	17,455	167	114,932
35		1,300	1,300	11	104,447	470		1,781	14,128	1,546	17,455	150	115,081
36		1,300	1,300	10	104,457	470		1,781	14,128	1,546	17,455	134	115,215
37		1,300	1,300	9	104,466	470		1,781	14,128	1,546	17,455	119	115,334
38		1,300	1,300	8	104,474	470		1,781	14,128	1,546	17,455	106	115,441
39		1,300	1,300	7	104,481	470		1,781	14,128	1,546	17,455	95	115,536
40		1,300	1,300	6	104,487	470		1,781	14,128	1,546	17,455	85	115,620
41		1,300	1,300	6	104,493	470		1,781	14,128	1,546	17,455	76	115,696
42		1,300	1,300	5	104,498	470		1,781	14,128	1,546	17,455	68	115,764
43		1,300	1,300	4	104,502	470		1,781	14,128	1,546	17,455	60	115,824
44		1,300	1,300	4	104,506	470		1,781	14,128	1,546	17,455	54	115,878
45		1,300	1,300	4	104,510	470		1,781	14,128	1,546	17,455	48	115,926
46		1,300	1,300	3	104,513	470		1,781	14,128	1,546	17,455	43	115,969
47		1,300	1,300	3	104,516	470		1,781	14,128	1,546	17,455	38	116,008
48		1,300	1,300	3	104,519	470		1,781	14,128	1,546	17,455	34	116,042
49		1,300	1,300	2	104,521	470		1,781	14,128	1,546	17,455	31	116,073
50		1,300	1,300	3	104,519	470	(31,667)	1,781	14,128	1,546	(14,212)	(23)	115,980

Cumulative Present Worth of Hydropower Costs:	104,519
Cumulative Present Worth of Thermal Costs:	115,980
Benefit-Cost Ratio @ 12%:	1.11
Equalizing Discount Rate:	14.0%

EXHIBIT 8-31

PROJECT NAME: AKBULUNSK

Installed Capacity (MW)	100.0	Coal Capacity Cost($/kW)	1600	Construction Cost	HYDRO	COAL
Dependable Capacity (MW)	24.0	Coal Fixed O&M Cost ($/kW-yr)	30.0	YEAR 1	15%	5%
Hydro Mechanical Availability	1.237	Variable Coal O&M Cost ($/MWh)	3.0	YEAR 2	30%	25%
Hydro Energy Generation (GWh)	372	Variable GT O&M Cost ($/MWh)	5.0	YEAR 3	35%	45%
Construction Cost ($*1000)	135,000	Coal Energy Value ($/MWh)	25.0	YEAR 4	20%	25%
O&M Cost ($/kW/year)	10.0	GT Energy Value ($/MWh)	60.0	TOTAL	100%	100%
		Coal Energy Generation (GWh)	201			
Discount Rate	12.0%	GT Energy Generation (GWh)	171			

	HYDROPOWER COSTS					THERMAL COSTS							
YEAR	Const. Cost	O&M Cost	Total Cost	Present Worth	Cum. Present Worth	Energy Gen.	Thermal Const. Cost	Fixed O&M Cost	Energy Cost	Variable O&M Cost	Total Cost	Present Worth	Cum. Present Worth
	20,250		20,250	14,414	14,414		2,375				2,375	1,691	1,691
	40,500		40,500	25,738	40,152		11,875				11,875	7,547	9,237
	47,250		47,250	26,811	66,963		21,375				21,375	12,129	21,366
	27,000		27,000	13,679	80,642		11,875				11,875	6,016	27,383
1		1,000	1,000	452	81,094	372		891	15,284	1,458	17,632	7,976	35,359
2		1,000	1,000	404	81,498	372		891	15,284	1,458	17,632	7,121	42,480
3		1,000	1,000	361	81,859	372		891	15,284	1,458	17,632	6,358	48,839
4		1,000	1,000	322	82,181	372		891	15,284	1,458	17,632	5,677	54,516
5		1,000	1,000	287	82,468	372		891	15,284	1,458	17,632	5,069	59,585
6		1,000	1,000	257	82,725	372		891	15,284	1,458	17,632	4,526	64,111
7		1,000	1,000	229	82,954	372		891	15,284	1,458	17,632	4,041	68,151
8		1,000	1,000	205	83,159	372		891	15,284	1,458	17,632	3,608	71,759
9		1,000	1,000	183	83,341	372		891	15,284	1,458	17,632	3,221	74,981
10		1,000	1,000	163	83,505	372		891	15,284	1,458	17,632	2,876	77,857
11		1,000	1,000	146	83,650	372		891	15,284	1,458	17,632	2,568	80,425
12		1,000	1,000	130	83,780	372		891	15,284	1,458	17,632	2,293	82,718
13		1,000	1,000	116	83,896	372		891	15,284	1,458	17,632	2,047	84,765
14		1,000	1,000	104	84,000	372		891	15,284	1,458	17,632	1,828	86,593
15		1,000	1,000	93	84,093	372		891	15,284	1,458	17,632	1,632	88,225
16		1,000	1,000	83	84,175	372		891	15,284	1,458	17,632	1,457	89,682
17		1,000	1,000	74	84,249	372		891	15,284	1,458	17,632	1,301	90,983
18		1,000	1,000	66	84,315	372		891	15,284	1,458	17,632	1,162	92,145
19		1,000	1,000	59	84,374	372		891	15,284	1,458	17,632	1,037	93,182
20		1,000	1,000	53	84,426	372		891	15,284	1,458	17,632	926	94,108
21		1,000	1,000	47	84,473	372		891	15,284	1,458	17,632	827	94,935
22		1,000	1,000	42	84,515	372		891	15,284	1,458	17,632	738	95,674
23		1,000	1,000	37	84,552	372		891	15,284	1,458	17,632	659	96,333
24		1,000	1,000	33	84,586	372		891	15,284	1,458	17,632	589	96,921
25		1,000	1,000	30	84,616	372		891	15,284	1,458	17,632	525	97,447
26		1,000	1,000	27	84,642	372		891	15,284	1,458	17,632	469	97,916
27		1,000	1,000	24	84,666	372	2,375	891	15,284	1,458	20,008	475	98,391
28		1,000	1,000	21	84,687	372	11,875	891	15,284	1,458	29,508	626	99,017
29		1,000	1,000	19	84,705	372	21,375	891	15,284	1,458	39,008	739	99,756
30	13,500	1,000	14,500	245	84,951	372	11,875	891	15,284	1,458	29,508	499	100,255
31		1,000	1,000	15	84,966	372		891	15,284	1,458	17,632	266	100,521
32		1,000	1,000	13	84,980	372		891	15,284	1,458	17,632	238	100,759
33		1,000	1,000	12	84,992	372		891	15,284	1,458	17,632	212	100,971
34		1,000	1,000	11	85,003	372		891	15,284	1,458	17,632	189	101,161
35		1,000	1,000	10	85,012	372		891	15,284	1,458	17,632	169	101,330
36		1,000	1,000	9	85,021	372		891	15,284	1,458	17,632	151	101,481
37		1,000	1,000	8	85,028	372		891	15,284	1,458	17,632	135	101,616
38		1,000	1,000	7	85,035	372		891	15,284	1,458	17,632	120	101,736
39		1,000	1,000	6	85,041	372		891	15,284	1,458	17,632	108	101,844
40		1,000	1,000	5	85,047	372		891	15,284	1,458	17,632	96	101,940
41		1,000	1,000	5	85,052	372		891	15,284	1,458	17,632	86	102,025
42		1,000	1,000	4	85,056	372		891	15,284	1,458	17,632	77	102,102
43		1,000	1,000	4	85,060	372		891	15,284	1,458	17,632	68	102,170
44		1,000	1,000	3	85,063	372		891	15,284	1,458	17,632	61	102,231
45		1,000	1,000	3	85,066	372		891	15,284	1,458	17,632	54	102,286
46		1,000	1,000	3	85,069	372		891	15,284	1,458	17,632	49	102,334
47		1,000	1,000	2	85,072	372		891	15,284	1,458	17,632	43	102,378
48		1,000	1,000	2	85,074	372		891	15,284	1,458	17,632	39	102,417
49		1,000	1,000	2	85,076	372		891	15,284	1,458	17,632	35	102,451
50		1,000	1,000	2	85,076	372	(15,834)	891	15,284	1,458	1,799	4	102,420

Cumulative Present Worth of Hydropower Costs:	85,076
Cumulative Present Worth of Thermal Costs:	102,420
Benefit-Cost Ratio @ 12%:	1.20
Equalizing Discount Rate:	15.2%

EXHIBIT 8-3

PROJECT NAME: NARYN 1

Installed Capacity (MW)	62.0	Coal Capacity Cost($/kW)	1600	Construction Cost	HYDRO	COAL
Dependable Capacity (MW)	14.0	Coal Fixed O&M Cost ($/kW-yr)	30.0	YEAR 1	15%	5%
Hydro Mechanical Availability	1.237	Variable Coal O&M Cost ($/MWh)	3.0	YEAR 2	30%	25%
Hydro Energy Generation (GWh)	227	Variable GT O&M Cost ($/MWh)	5.0	YEAR 3	35%	45%
Construction Cost ($*1000)	96,829	Coal Energy Value ($/MWh)	25.0	YEAR 4	20%	25%
O&M Cost ($/kW/year)	10.0	GT Energy Value ($/MWh)	60.0	TOTAL	100%	100%
		Coal Energy Generation (GWh)	117			
Discount Rate	12.0%	GT Energy Generation (GWh)	110			

	HYDROPOWER COSTS					THERMAL COSTS							
YEAR	Const. Cost	O&M Cost	Total Cost	Present Worth	Cum. Present Worth	Energy Gen.	Thermal Const. Cost	Fixed O&M Cost	Energy Cost	Variable O&M Cost	Total Cost	Present Worth	Cum. Present Worth
	14,524		14,524	10,338	10,338		1,775				1,385	986	986
	29,049		29,049	18,461	28,799		6,927				6,927	4,402	5,388
	33,890		33,890	19,230	48,029		12,469				12,469	7,075	12,464
	19,356		19,366	9,811	57,841		6,927				6,927	3,510	15,973
1		620	620	280	58,121	227		520	9,516	900	10,936	4,947	20,920
2		620	620	250	58,371	227		520	9,516	900	10,936	4,417	25,337
3		620	620	224	58,595	227		520	9,516	900	10,936	3,943	29,280
4		620	620	200	58,795	227		520	9,516	900	10,936	3,521	32,801
5		620	620	178	58,973	227		520	9,516	900	10,936	3,144	35,945
6		620	620	159	59,132	227		520	9,516	900	10,936	2,807	38,752
7		620	620	142	59,274	227		520	9,516	900	10,936	2,506	41,258
8		620	620	127	59,401	227		520	9,516	900	10,936	2,238	43,496
9		620	620	113	59,514	227		520	9,516	900	10,936	1,998	45,493
10		620	620	101	59,615	227		520	9,516	900	10,936	1,784	47,277
11		620	620	90	59,706	227		520	9,516	900	10,936	1,593	48,870
12		620	620	81	59,786	227		520	9,516	900	10,936	1,422	50,292
13		620	620	72	59,858	227		520	9,516	900	10,936	1,270	51,562
14		620	620	64	59,923	227		520	9,516	900	10,936	1,134	52,695
15		620	620	57	59,980	227		520	9,516	900	10,936	1,012	53,708
16		620	620	51	60,031	227		520	9,516	900	10,936	904	54,611
17		620	620	46	60,077	227		520	9,516	900	10,936	807	55,418
18		620	620	41	60,118	227		520	9,516	900	10,936	720	56,139
19		620	620	36	60,154	227		520	9,516	900	10,936	643	56,782
20		620	620	33	60,187	227		520	9,516	900	10,936	574	57,356
21		620	620	29	60,216	227		520	9,516	900	10,936	513	57,869
22		620	620	26	60,242	227		520	9,516	900	10,936	458	58,327
23		620	620	23	60,265	227		520	9,516	900	10,936	409	58,736
24		620	620	21	60,286	227		520	9,516	900	10,936	365	59,101
25		620	620	18	60,304	227		520	9,516	900	10,936	326	59,427
26		620	620	16	60,321	227		520	9,516	900	10,936	291	59,718
27		620	620	15	60,335	227	1,385	520	9,516	900	12,321	293	60,010
28		620	620	13	60,349	227	6,927	520	9,516	900	17,863	379	60,389
29		620	620	12	60,360	227	12,469	520	9,516	900	23,405	443	60,833
30	9,683	620	10,303	174	60,535	227	6,927	520	9,516	900	17,863	302	61,135
31		620	620	9	60,544	227		520	9,516	900	10,936	165	61,300
32		620	620	8	60,552	227		520	9,516	900	10,936	147	61,447
33		620	620	7	60,560	227		520	9,516	900	10,936	132	61,579
34		620	620	7	60,566	227		520	9,516	900	10,936	118	61,696
35		620	620	6	60,572	227		520	9,516	900	10,936	105	61,801
36		620	620	5	60,578	227		520	9,516	900	10,936	94	61,895
37		620	620	5	60,582	227		520	9,516	900	10,936	84	61,979
38		620	620	4	60,587	227		520	9,516	900	10,936	75	62,053
39		620	620	4	60,590	227		520	9,516	900	10,936	67	62,120
40		620	620	3	60,594	227		520	9,516	900	10,936	60	62,180
41		620	620	3	60,597	227		520	9,516	900	10,936	53	62,233
42		620	620	3	60,600	227		520	9,516	900	10,936	47	62,280
43		620	620	2	60,602	227		520	9,516	900	10,936	42	62,323
44		620	620	2	60,604	227		520	9,516	900	10,936	38	62,360
45		620	620	2	60,606	227		520	9,516	900	10,936	34	62,394
46		620	620	2	60,608	227		520	9,516	900	10,936	30	62,424
47		620	620	2	60,609	227		520	9,516	900	10,936	27	62,451
48		620	620	1	60,611	227		520	9,516	900	10,936	24	62,475
49		620	620	1	60,612	227		520	9,516	900	10,936	21	62,497
50		620	620	1	60,612	227	(9,236)	520	9,516	900	1,699	3	62,479

Cumulative Present Worth of Hydropower Costs:	60,612
Cumulative Present Worth of Thermal Costs:	62,479
Benefit-Cost Ratio @ 12%:	1.03
Equalizing Discount Rate:	12.5%

EXHIBIT 8-33

PROJECT NAME: NARYN 2

Installed Capacity (MW)	60.0	Coal Capacity Cost($/kW)	1600	Construction Cost	HYDRO	COAL
Dependable Capacity (MW)	15.0	Coal Fixed O&M Cost ($/kW-yr)	30.0	YEAR 1	15%	5%
Hydro Mechanical Availability	1.237	Variable Coal O&M Cost ($/MWh)	3.0	YEAR 2	30%	25%
Hydro Energy Generation (GWh)	235	Variable GT O&M Cost ($/MWh)	5.0	YEAR 3	35%	45%
Construction Cost ($*1000)	100,000	Coal Energy Value ($/MWh)	25.0	YEAR 4	20%	25%
O&M Cost ($/kW/year)	10.0	GT Energy Value ($/MWh)	60.0	TOTAL	100%	100%
		Coal Energy Generation (GWh)	126			
Discount Rate	12.0%	GT Energy Generation (GWh)	109			

	HYDROPOWER COSTS					THERMAL COSTS							
YEAR	Const. Cost	O&M Cost	Total Cost	Present Worth	Cum. Present Worth	Energy Gen.	Thermal Const. Cost	Fixed O&M Cost	Energy Cost	Variable O&M Cost	Total Cost	Present Worth	Cum. Present Worth
	15,000		15,000	10,677	10,677		1,484				1,484	1,057	1,057
	30,000		30,000	19,066	29,742		7,422				7,422	4,717	5,773
	35,000		35,000	19,860	49,602		13,360				13,360	7,581	13,354
	20,000		20,000	10,133	59,735		7,422				7,422	3,760	17,114
1		600	600	271	60,006	235		557	9,702	924	11,183	5,059	22,173
2		600	600	242	60,249	235		557	9,702	924	11,183	4,517	26,689
3		600	600	216	60,465	235		557	9,702	924	11,183	4,033	30,722
4		600	600	193	60,658	235		557	9,702	924	11,183	3,601	34,322
5		600	600	172	60,831	235		557	9,702	924	11,183	3,215	37,537
6		600	600	154	60,985	235		557	9,702	924	11,183	2,870	40,408
7		600	600	138	61,122	235		557	9,702	924	11,183	2,563	42,970
8		600	600	123	61,245	235		557	9,702	924	11,183	2,288	45,259
9		600	600	110	61,354	235		557	9,702	924	11,183	2,043	47,302
10		600	600	98	61,452	235		557	9,702	924	11,183	1,824	49,126
11		600	600	87	61,540	235		557	9,702	924	11,183	1,629	50,755
12		600	600	78	61,618	235		557	9,702	924	11,183	1,454	52,209
13		600	600	70	61,687	235		557	9,702	924	11,183	1,298	53,507
14		600	600	62	61,750	235		557	9,702	924	11,183	1,159	54,666
15		600	600	56	61,805	235		557	9,702	924	11,183	1,035	55,701
16		600	600	50	61,855	235		557	9,702	924	11,183	924	56,626
17		600	600	44	61,899	235		557	9,702	924	11,183	825	57,451
18		600	600	40	61,939	235		557	9,702	924	11,183	737	58,188
19		600	600	35	61,974	235		557	9,702	924	11,183	658	58,845
20		600	600	32	62,006	235		557	9,702	924	11,183	587	59,433
21		600	600	28	62,033	235		557	9,702	924	11,183	524	59,957
22		600	600	25	62,059	235		557	9,702	924	11,183	468	60,425
23		600	600	22	62,081	235		557	9,702	924	11,183	418	60,843
24		600	600	20	62,101	235		557	9,702	924	11,183	373	61,217
25		600	600	18	62,119	235		557	9,702	924	11,183	333	61,550
26		600	600	16	62,135	235		557	9,702	924	11,183	298	61,847
27		600	600	14	62,149	235	1,484	557	9,702	924	12,667	301	62,148
28		600	600	13	62,162	235	7,422	557	9,702	924	18,605	395	62,543
29		600	600	11	62,173	235	13,360	557	9,702	924	24,542	465	63,008
30	10,000	600	10,600	179	62,353	235	7,422	557	9,702	924	18,605	315	63,322
31		600	600	9	62,362	235		557	9,702	924	11,183	169	63,491
32		600	600	8	62,370	235		557	9,702	924	11,183	151	63,642
33		600	600	7	62,377	235		557	9,702	924	11,183	135	63,777
34		600	600	6	62,383	235		557	9,702	924	11,183	120	63,897
35		600	600	6	62,389	235		557	9,702	924	11,183	107	64,004
36		600	600	5	62,394	235		557	9,702	924	11,183	96	64,100
37		600	600	5	62,399	235		557	9,702	924	11,183	86	64,186
38		600	600	4	62,403	235		557	9,702	924	11,183	76	64,262
39		600	600	4	62,407	235		557	9,702	924	11,183	68	64,330
40		600	600	3	62,410	235		557	9,702	924	11,183	61	64,391
41		600	600	3	62,413	235		557	9,702	924	11,183	54	64,445
42		600	600	3	62,415	235		557	9,702	924	11,183	49	64,494
43		600	600	2	62,418	235		557	9,702	924	11,183	43	64,537
44		600	600	2	62,420	235		557	9,702	924	11,183	39	64,576
45		600	600	2	62,422	235		557	9,702	924	11,183	35	64,610
46		600	600	2	62,423	235		557	9,702	924	11,183	31	64,641
47		600	600	1	62,425	235		557	9,702	924	11,183	28	64,669
48		600	600	1	62,426	235		557	9,702	924	11,183	25	64,693
49		600	600	1	62,427	235		557	9,702	924	11,183	22	64,715
50		600	600	1	62,427	235	(9,896)	557	9,702	924	1,287	3	64,696

Cumulative Present Worth of Hydropower Costs:	62,427
Cumulative Present Worth of Thermal Costs:	64,696
Benefit-Cost Ratio @ 12%:	1.04
Equalizing Discount Rate:	12.5%

EXHIBIT 8-34

PROJECT NAME: NARYN 3

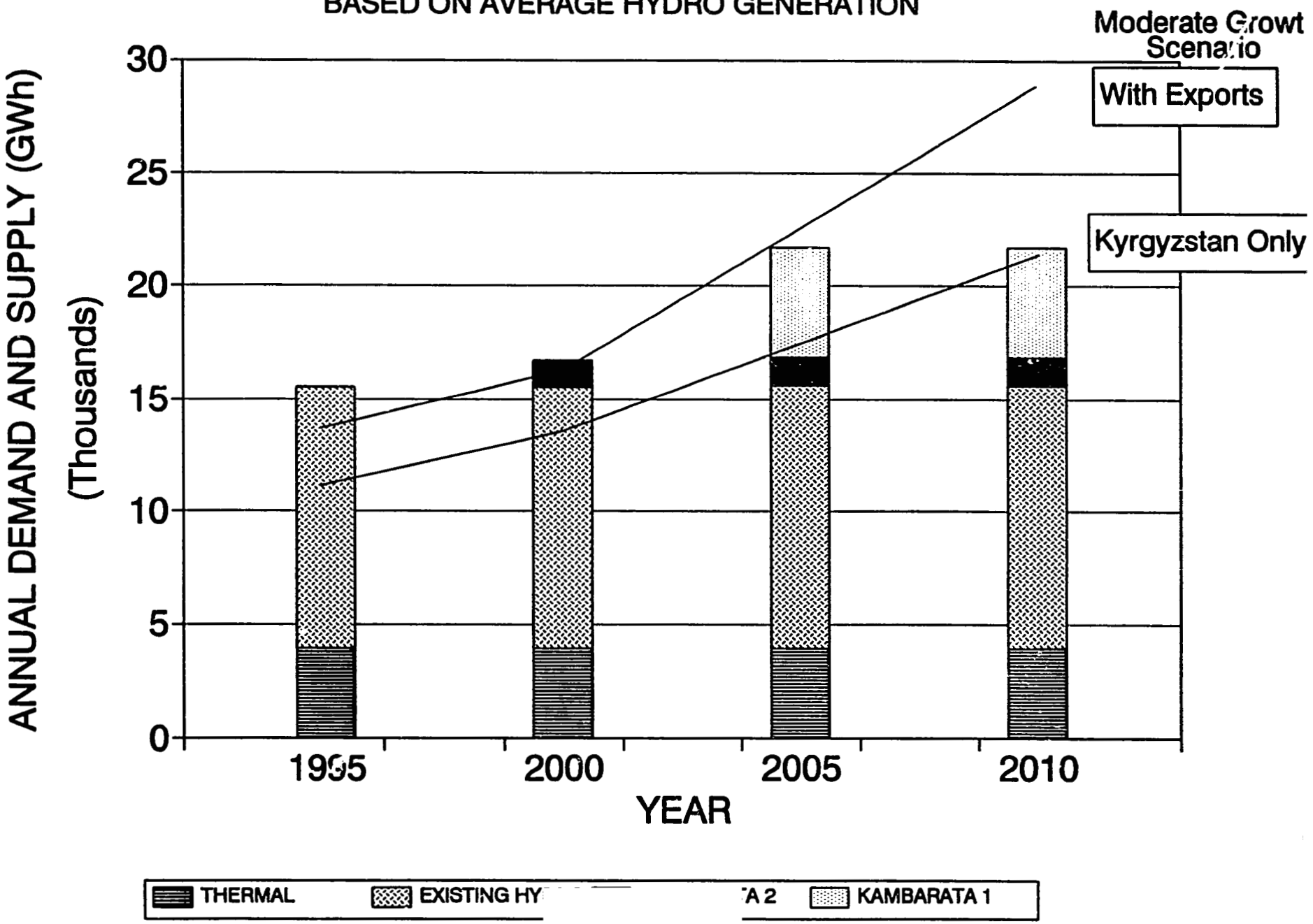
Installed Capacity (MW)	60.0	Coal Capacity Cost($/kW)	1600	Construction Cost	HYDRO	COAL
Dependable Capacity (MW)	[illegible]	Coal Fixed O&M Cost ($/kW-yr)	30.0	YEAR 1	15%	5%
Hydro Mechanical Availability	1.237	Variable Coal O&M Cost ($/MWh)	3.0	YEAR 2	30%	25%
Hydro Energy Generation (GWh)	254	Variable GT O&M Cost ($/MWh)	5.0	YEAR 3	35%	45%
Construction Cost ($*1000)	115,000	Coal Energy Value ($/MWh)	25.0	YEAR 4	20%	25%
O&M Cost ($/kW/year)	10.0	GT Energy Value ($/MWh)	60.0	TOTAL	100%	100%
		Coal Energy Generation (GWh)	142			
Discount Rate	12.0%	GT Energy Generation (GWh)	112			

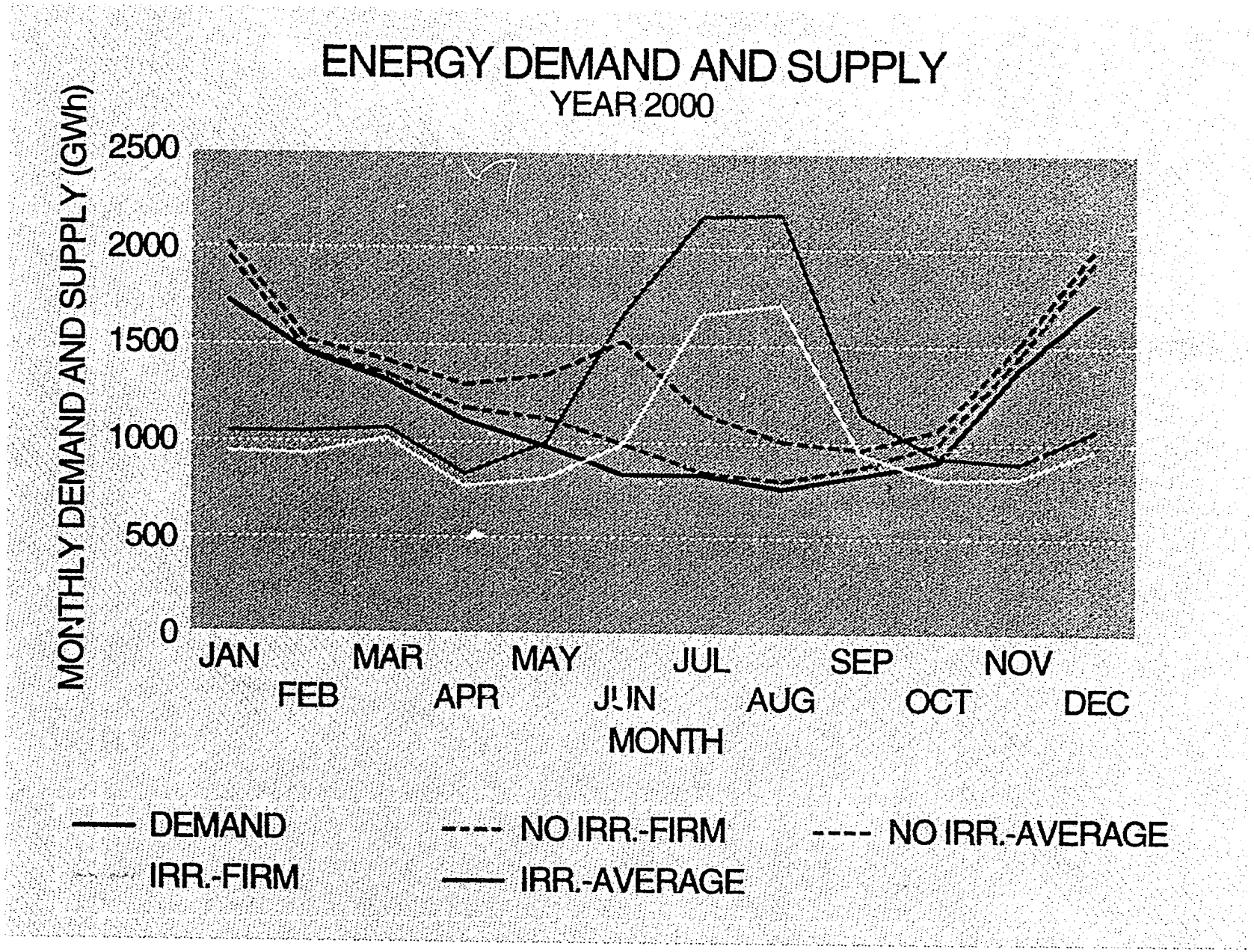
	HYDROPOWER COSTS					THERMAL COSTS							
YEAR	Const. Cost	O&M Cost	Total Cost	Present Worth	Cum. Present Worth	Energy Gen.	Thermal Const. Cost	Fixed O&M Cost	Energy Cost	Variable O&M Cost	Total Cost	Present Worth	Cum. Present Worth
	17,250		17,250	12,278	12,278		1,682				1,682	1,197	1,197
	34,500		34,500	21,925	34,204		8,412				8,412	5,346	6,543
	40,250		40,250	22,839	57,043		15,141				15,141	8,591	15,135
	23,000		23,000	11,653	68,695		8,412				8,412	4,262	19,396
1		600	600	271	68,966	254		631	10,256	985	11,872	5,370	24,766
2		600	600	242	69,209	254		631	10,256	985	11,872	4,795	29,561
3		600	600	216	69,425	254		631	10,256	985	11,872	4,281	33,843
4		600	600	193	69,618	254		631	10,256	985	11,872	3,823	37,665
5		600	600	172	69,791	254		631	10,256	985	11,872	3,413	41,078
6		600	600	154	69,945	254		631	10,256	985	11,872	3,047	44,125
7		600	600	138	70,082	254		631	10,256	985	11,872	2,721	46,846
8		600	600	123	70,205	254		631	10,256	985	11,872	2,429	49,275
9		600	600	110	70,315	254		631	10,256	985	11,872	2,169	51,444
10		600	600	98	70,413	254		631	10,256	985	11,872	1,937	53,381
11		600	600	87	70,500	254		631	10,256	985	11,872	1,729	55,110
12		600	600	78	70,578	254		631	10,256	985	11,872	1,544	56,654
13		600	600	70	70,648	254		631	10,256	985	11,872	1,378	58,032
14		600	600	62	70,710	254		631	10,256	985	11,872	1,231	59,263
15		600	600	56	70,765	254		631	10,256	985	11,872	1,099	60,362
16		600	600	50	70,815	254		631	10,256	985	11,872	981	61,343
17		600	600	44	70,859	254		631	10,256	985	11,872	876	62,219
18		600	600	40	70,899	254		631	10,256	985	11,872	782	63,001
19		600	600	35	70,934	254		631	10,256	985	11,872	698	63,700
20		600	600	32	70,966	254		631	10,256	985	11,872	624	64,323
21		600	600	28	70,994	254		631	10,256	985	11,872	557	64,880
22		600	600	25	71,019	254		631	10,256	985	11,872	497	65,377
23		600	600	22	71,041	254		631	10,256	985	11,872	444	65,821
24		600	600	20	71,061	254		631	10,256	985	11,872	396	66,217
25		600	600	18	71,079	254		631	10,256	985	11,872	354	66,571
26		600	600	16	71,095	254		631	10,256	985	11,872	316	66,887
27		600	600	14	71,109	254	1,682	631	10,256	985	13,554	322	67,209
28		600	600	13	71,122	254	8,412	631	10,256	985	20,284	430	67,639
29		600	600	11	71,133	254	15,141	631	10,256	985	27,013	512	68,151
30	11,500	600	12,100	205	71,338	254	8,412	631	10,256	985	20,284	343	68,494
31		600	600	9	71,347	254		631	10,256	985	11,872	179	68,673
32		600	600	8	71,355	254		631	10,256	985	11,872	160	68,833
33		600	600	7	71,362	254		631	10,256	985	11,872	143	68,976
34		600	600	6	71,369	254		631	10,256	985	11,872	128	69,104
35		600	600	6	71,375	254		631	10,256	985	11,872	114	69,218
36		600	600	5	71,380	254		631	10,256	985	11,872	102	69,319
37		600	600	5	71,384	254		631	10,256	985	11,872	91	69,410
38		600	600	4	71,389	254		631	10,256	985	11,872	81	69,491
39		600	600	4	71,392	254		631	10,256	985	11,872	72	69,564
40		600	600	3	71,395	254		631	10,256	985	11,872	65	69,628
41		600	600	3	71,398	254		631	10,256	985	11,872	58	69,686
42		600	600	3	71,401	254		631	10,256	985	11,872	52	69,737
43		600	600	2	71,403	254		631	10,256	985	11,872	46	69,783
44		600	600	2	71,405	254		631	10,256	985	11,872	41	69,825
45		600	600	2	71,407	254		631	10,256	985	11,872	37	69,861
46		600	600	2	71,409	254		631	10,256	985	11,872	33	69,894
47		600	600	1	71,410	254		631	10,256	985	11,872	29	69,923
48		600	600	1	71,412	254		631	10,256	985	11,872	26	69,949
49		600	600	1	71,413	254		631	10,256	985	11,872	23	69,973
50		600	600	1	71,413	254	(11,215)	631	10,256	985	657	1	69,951

Cumulative Present Worth of Hydropower Costs:	71,413
Cumulative Present Worth of Thermal Costs:	69,951
Benefit-Cost Ratio @ 12%:	0.98
Equalizing Discount Rate:	11.7%

ENERGY GENERATION DEMAND AND SUPPLY

BASED ON AVERAGE HYDRO GENERATION




ENERGY DEMAND AND SUPPLY
YEAR 2000
MONTHLY DEMAND AND SUPPLY (GWh)
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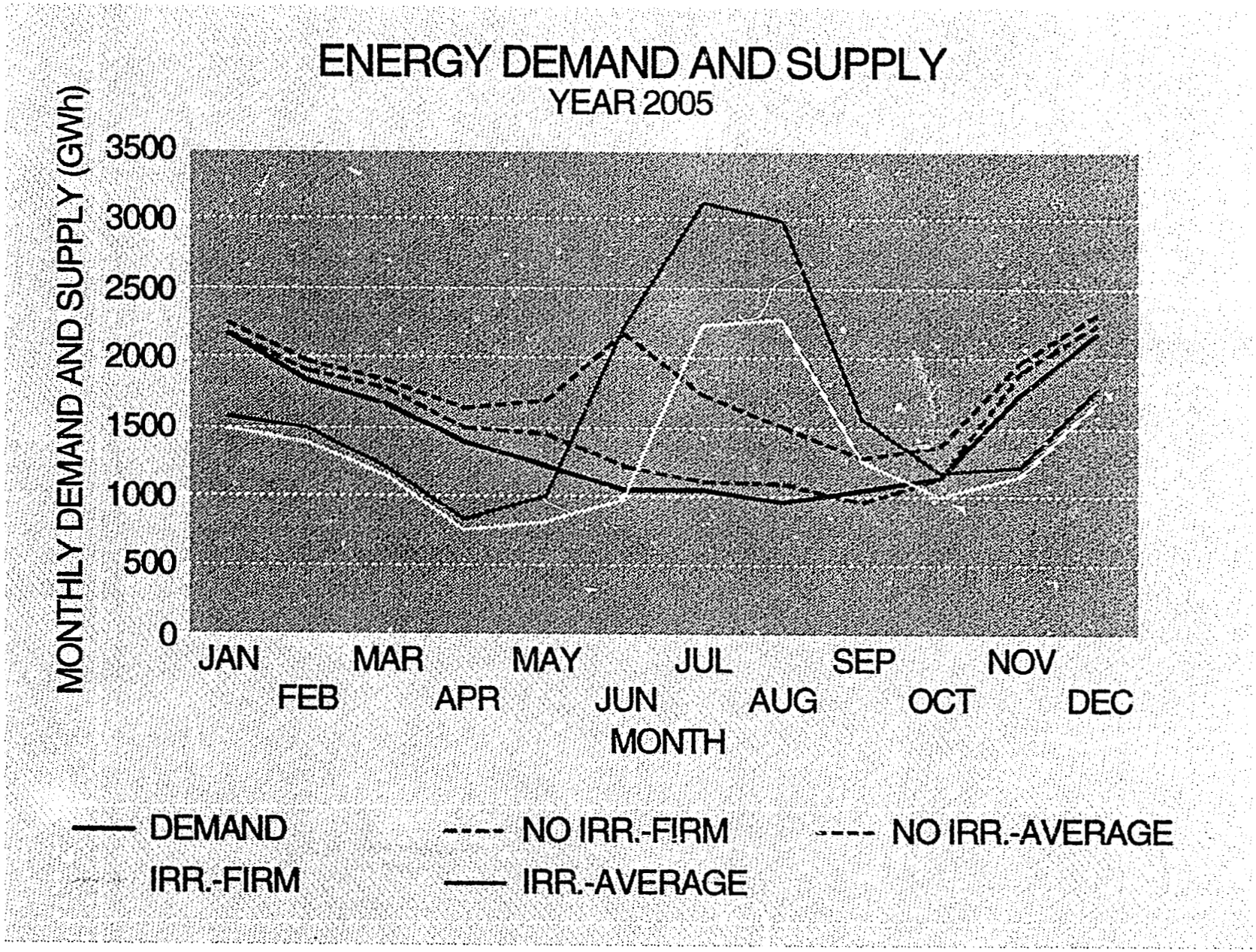
2000
1500
1000
500
0
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
MONTH
DEMAND
IRR.-FIRM
NO IRR.-FIRM
IRR.-AVERAGE
NO IRR.-AVERAGE

EXHIBIT 8-36


ENERGY DEMAND AND SUPPLY
YEAR 2005
MONTHLY DEMAND AND SUPPLY (GWh)
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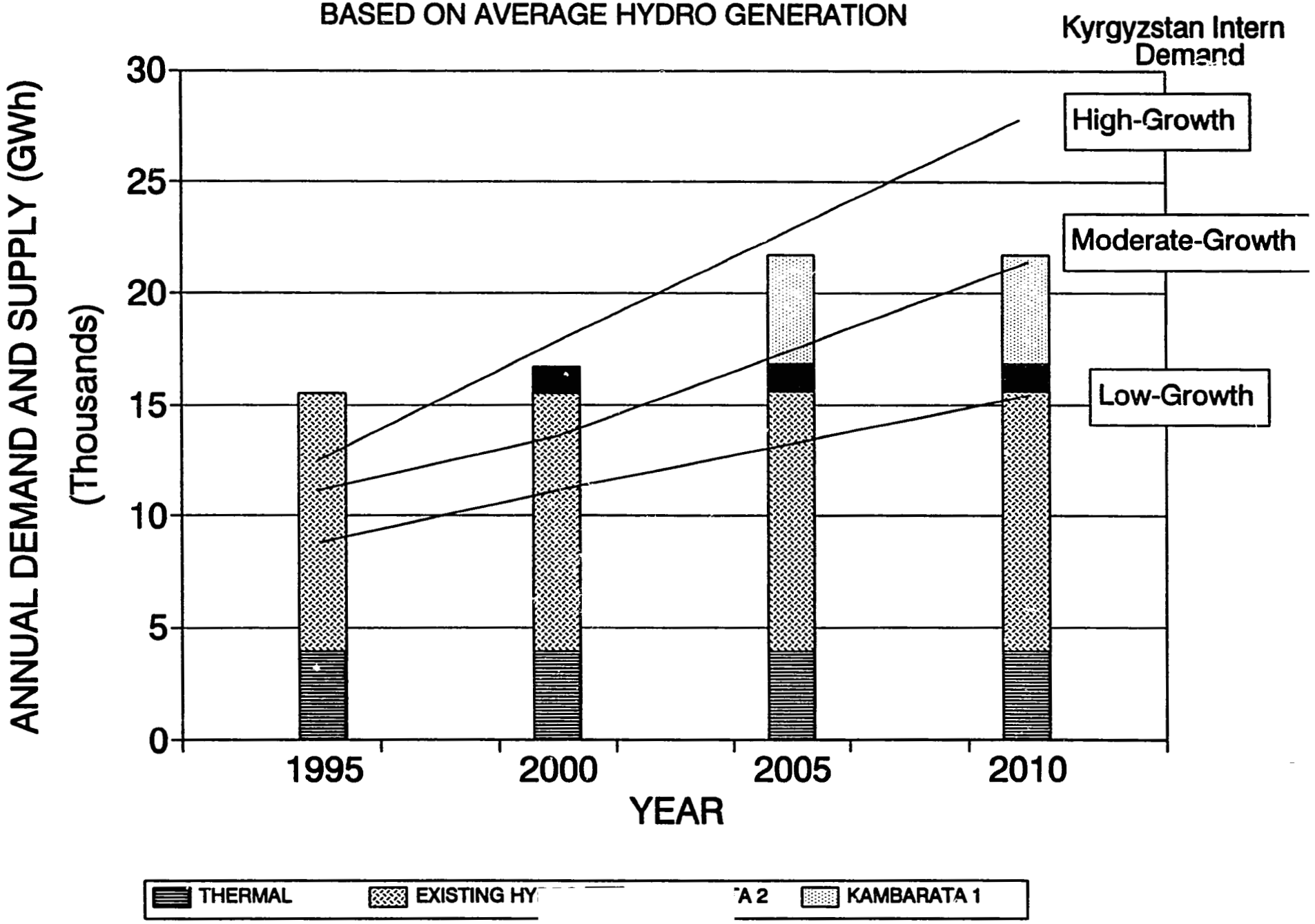
3000
2500
2000
1500
1000
500
0
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
MONTH
DEMAND
NO IRR.-FIRM
NO IRR.-AVERAGE
IRR.-FIRM
IRR.-AVERAGE

EXHIBIT 8-37

ENERGY GENERATION DEMAND AND SUPPLY

BASED ON AVERAGE HYDRO GENERATION



ENERGY GENERATION DEMAND AND SUPPLY

BASED ON FIRM HYDRO GENERATION

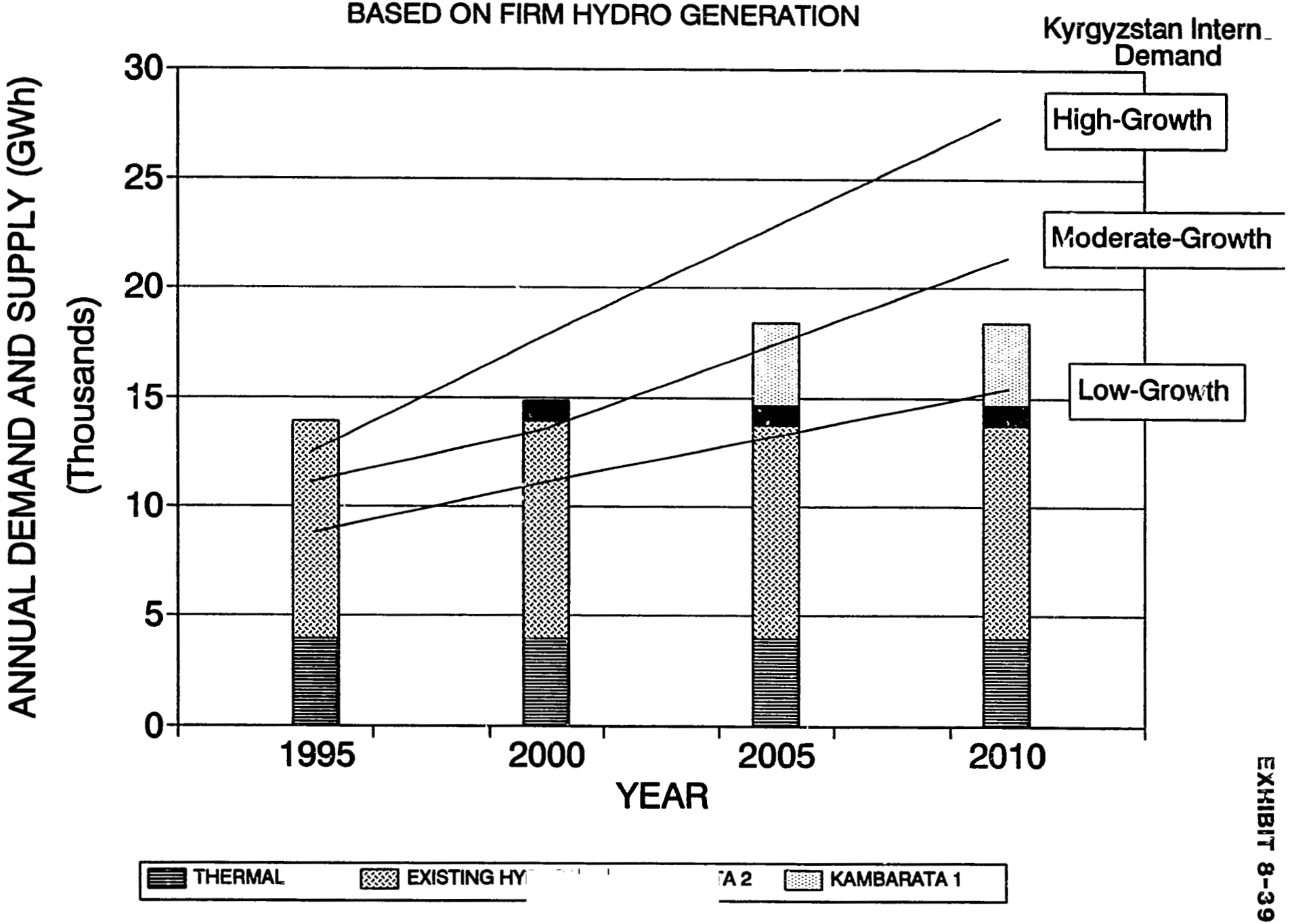


EXHIBIT 8-39

Chapter 9

FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

9.1 Energy Demand and Future Growth

Changing economic and political conditions have affected current demand and future growth. Recent decline in industrial consumption has been more than offset by a major increase in residential demand. The price of thermal fuel (coal, gas or oil) used for residential heating has drastically increased over the past two years while the price of electricity has remained very low. This has resulted in a shift towards electric heating appliances and a 75 percent increase in the residential demand between 1990 and 1992.

Despite the large increase in residential consumption, the average household consumption and per capita electricity use are still very low. There is potential for significant increase in demand.

Over the mid- and long-term, growth in electrical demand remains dependent upon the restructuring of the industries, growth in economic activities, and external financing.

The internal demand of Kyrgyzstan would vary between 10,000 and 15,000 GWh in year 2000 and 13,000 to 24,000 GWh in year 2010. Net exports are expected to be between 2,000 and 6,500 GWh per year. The peak demand is in December or January. Summer demand is expected to be about 60 percent of the winter peak.

9.2 Energy Supply

There is an adequate supply of electricity from the existing powerplants to meet current demand. Production cost is stable and relatively low due to the 75 percent share of hydroelectric generation.

Due to the excess hydroelectric generation during the summer as a result of irrigation releases, seasonal exchanges of energy are required with the neighboring republics.

The summer irrigation releases deprive Kyrgyzstan of indegeneous generation during the winter months when demand is at its maximum.

Projects underway (Kambarata 1 and 2) offer low-cost energy.

9.3 Hydropower Operation Studies

Hydropower operation studies were performed to estimate dependable and average monthly energy generation. Due to irrigation requirements for Uzbekistan and Kazakstan, current operation of the Lower Naryn projects (Toktogul and the downstrean hydro projects) creates a large surplus of energy during the summer. Historically, this energy surplus was absorbed by the power grids of Uzbekistan and Kazakstan.

A series of alternative reservoir operation runs were made to optimize the operation of the Lower Naryn projects without regard to downstream irrigation requirements. Instead of storing water for summer irrigation release, the projects are operated to meet the internal power demand of Kyrgyzstan which is greater during the winter months. Under this scenario, the existing hydro and thermal facilities could meet the current internal demand of Kyrgyzstan without any power shortages during the winter months.

9.4 Future Hydro Generation Options

The potential hydroelectric capacity of Kyrgyzstan is estimated at 26,000 MW. To date, about 2,700 MW has been developed. The development of the Naryn river and its affluents has been planned by the KSEC and the THDI for many years. The first phase of this program included the development of the Lower Naryn river with the construction of the multi-year Toktogul reservoir and the four downstream projects. To provide much needed generation during the winter and meet continued demand growth, the next phase was to develop the Kambarata projects which were found to be the most economically attractive projects.

The results of our studies show that the Kambarata 1 and 2 projects are technically and economically feasible. They would provide substantial and valuable winter energy and meet future demand. Being located upstream of the Toktogul reservoir, the winter releases from the Kambarata projects would be stored in the Toktogul reservoir to allow for full summer irrigation releases required in Uzbekistan and Kazakstan.

Other projects analyzed in this study are smaller in size and do not have adequate seasonal storage. Hydropower addition to existing irrigation projects such as the Kirov reservoir would generate mostly during the summer season when there is already excess hydro energy and are therefore marginally attractive at this time.

There are however a number of additional sites which have been preliminary studied in the past by the THDI. The THDI has planned the development of the entire Naryn basin. A series of projects could be developed after the Kambarata projects.

Other small and mini hydro projects were developed in the 1920's and 1930's and have been

abandoned. These projects are close to local electrical load centers. Their rehabilitation could be economically attractive. This should be analyzed, along with finding alternative ways to implement these projects through local developers. This would allow the development of the private sector of Kyrgyzstan.

9.5 Economic Considerations

The Kambarata 1 and 2 projects are very competitive with thermal powerplants priced at world market prices. The projects are economically attractive and their development should receive first priority in the electric power expansion program.

Due to summer irrigation releases, Kyrgyzstan looses considerable power benefits from its reservoirs. Water stored behind its reservoirs can be priced at the value of dependable capacity and energy lost to the Kyrgyzstan power system.

Hydroplants at existing irrigation reservoir such as the Kirov project are subject to irrigation releases that deprive them of full power benefits. As a result, these projects are marginally attractive.

Based on preliminary cost estimates and evaluation of thermal costs, the Upper Naryn projects have attractive Benefit-Cost ratios varying between 0.74 and 1.20.

9.6 Integration of Demand and Supply

Hydropower generation represents about 75 percent of total generation. The remaining generation is provided by thermal facilities which are also used for district heating.

Due to irrigation releases in the summer months, there is an excess of electricity generation in the summer and a deficit in the winter months. Historically, this was compensated by power exchanges with Uzbekistan and Kazakstan and controlled by the former Soviet Union. Currently, new agreements are being negotiated on short-term basis.

Over the next five years, the existing thermal and hydro facilities will be sufficient to meet the internal demand of Kyrgyzstan, assuming that there will be a continuation of power exchanges with the other republics of Central Asia to meet the winter deficits.

A series of dry years, however, would require large releases of water during the summer seasons to meet irrigation requirements. This would lower the Toktogul reservoir elevation and sharply decrease the amount of energy that could be generated from this project. In such an event, Kyrgyzstan would have to rely on greater imports or face major power shortages.

As the electric demand continue to grow, there will be an imbalance between imports and exports. Due to the forecasted sharp increase in electric heating, electricity imports during the winter months would have to increase rapidly affecting the economy of Kygyzstan. Based on the Moderate Growth scenario, new generating facilities should come on line starting in the later part of the 1990's. The Kambarata projects are the most economically attractive projects and should be given priority.

9.7 Project Implementation

Since Kyrgyzstan does not have the financial resources to develop alone the large-scale Kambarata projects, implementation of these projects would have to be coordinated with the other republics of Central Asia and international lending agencies.

Uzbekistan and Kazakstan are the most likely candidates to participate in the development of these hydropower projects. Both republics received important irrigation benefits from the current operation of the existing hydro facilities and have an interest in maintaining a reliable supply of water for dry years. Development of the Kambarata projects which are upstream of the multi-year Toktogul reservoir would provide a major increase of hydropower generation in the winter months while maintaining water storage in the Toktogul reservoir for irrigation purposes.

In addition, Russia would most likely be involved with the supply of construction and permanent equipment. It was directly involved in the construction of all existing projects, and some permanent equipment has already been ordered for the Kambarata 2 project.

Due to the economic situation in Kyrgyzstan, international lending agencies will have to take the lead in organizing the construction financing of these projects. The European Bank for Reconstruction and Development (EBRD) has already funded the preparation of a project report for the Kambarata 2 project. The report will be ready in November 1993. Meetings are being held with the KSEC to discuss EBRD's involvement in the financing of the completion of the Kambarata 2 project.

Delays in the construction of the Kambarata projects would cause serious potential conflicts with the other republics of Central Asia. Without the additional winter energy to be generated by these projects, Kyrgyzstan would have to change the operating regime of the Toktogul project, therefore reducing the amount of water available for irrigation in Uzbekistan and Kazakstan.

9.8 Conclusion and Recommendations

Future electricity demand outlook, trade (exports) incentives, and operational benefits relative to costs indicate that the construction of the Kambarata 1 and 2 hydropower projects should be pursued as a top priority of the Government of Kyrgyzstan. The Kambarata 2 project is already under construction and major works such as power tunnels are well underway. About 30 percent of the construction is complete but a current lack of funding has brought construction activities to a halt. The European Bank for Reconstruction and Development (EBRD) has performed a parallel study on this project and is already looking into financing options to complete the Kambarata 2 project. At the same time, preparation of technical and financial documents required for financing the implementation of the Kambarata 1 project should continue.

The export of hydro electricity from Kyrgyzstan to Uzbekistan and Kazakhstan should also be considered into the overall energy balance of payments for Kyrgyzstan. Kyrgyzstan has severe energy deficits and imports coal, oil and gas from both Uzbekistan and Kazakhstan. At the same time, these two countries have vested interests in the operation of the Toktogul reservoir to maintain adequate storage for summer irrigation releases, specially during drought years. Development of the Kambarata projects would provide a major increase of hydropower generation in the winter months while maintaining water storage in the Toktogul reservoir for irrigation purposes. A strong cooperation between these countries and international lending agencies would make the implementation of the Kambarata projects very attractive, both for power and irrigation benefits.

Further activities are recommended:

<u>Kambarata Projects</u>

(1) The Government of Kyrgyzstan should declare that the completion of the Kambarata 2 project is a top funding priority.

(2) The design of the Kambarata 2 project should be refined for an initial 240 MW development with provision to add a third 120 MW unit.

(3) All necessary technical and financing-related information should be compiled for the preparation of tender documents for civil works and equipment supply and Banks' approval of construction financing for the Kambarata 2 project.

(4) The configuration of the dam for the Kambarata 1 project should be finalized through a comparison of the proposed controlled blasting techniques to a more conventional design such as concrete arch dam. Staging development and ways to reduce initial investment should also be considered.

(5) Contacts should be made with neighboring countries to discuss their potential participation in the development of the Kambarata projects.

General Hydropower-Sector Activities

(1) Existing contractual agreements between the Central Asian republics regarding the use and operation of the Toktogul reservoir and other uses of the Naryn and Syrdaya rivers for irrigation and power should be reviewed. Long-term operating criteria for the Toktogul project should be developed that are acceptable to all parties, and benefits and costs should be established.

(2) The electricity export potential to the neighboring republics and other countries nearby should be delineated, and legal and contractual documents related to short- and long-term power exchanges between Kyrgyzstan and the various Central Asian republics should be negotiated.

(3) Sources of international and local financing should be secured, and an appropriate legal and institutional structure (e.g., a joint-stock corporation) should be established to develop hydroelectric projects.

(4) The need for rehabilitation/upgrade and expansion of the transmission/distribution network of Kyrgyzstan to meet increased level of electrification, residential electric heating demand, and export should be planned. Tender documents for equipment supply should be prepared.

(5) The need for improvements in telecommunications and controls between the dispatch centers of Kyrgyzstan and other Central Asia republics should be assessed.