CENTRAL ASIA NATURAL RESOURCES MANAGEMENT PROGRAM

TRANSBOUNDARY WATER AND ENERGY PROJECT

AN INITIAL ASSESSMENT OF KAMBARATA 1 AND 2 HYDROPOWER PROJECTS

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LIST OF ACRONYMS

bcm	Billion cubic meters
BVO	River Basin Organization
	Central Asian Power System
	Combined Heat and Power Plant
EDR	Equalizing Discount Rate
ERR	Economic Rate of Return
GWh	Gigawatt hour
kV	Kilovolt
kW	Kilowatt
kWh	Kilowatt hour
mcm	Million cubic meters
MUV Index	Index of the Value of Manufactured Export
MW	Megawatt
NRMP	Central Asia Natural Resources Management Program
PA	PA Government Services, Inc.
SEA	State Energy Agency
TWEP	Transboundary Water and Energy Project
UDC	Unified Dispatch Center
USAID	United States Agency for International Development

EXECUTIVE SUMMARY

The Kambarata 1 and Kambarata 2 Hydropower Projects in Kyrgyzstan were identified under the Soviet regime as logical additions to the integrated Central Asian Power System (CAPS). In 1993 the projects were the subjects of an evaluation study funded by the United States Agency for International Development (USAID) and carried out by Harza Engineering Company. The World Bank and other international financial institutions, donors, and government agencies have expressed continued interest in the linkages between water and energy in the Aral Sea Basin. In this context, Kambarata 1 has attracted attention because it would help to resolve the long-term winter electric power shortages in Kyrgyzstan that, in turn, exacerbate conflicts between the use of water for irrigation and energy generation in the Syr Darya Basin.

More recently, USAID requested that PA Government Services, Inc. (PA), under its contracts for the Central Asia Natural Resources Management Program (NRMP) and Transboundary Water and Energy Project (TWEP), conduct an initial assessment of the proposed Kambarata 1 and Kambarata 2 Hydropower Projects to determine if and how the projects might contribute to resolving the regional electric power supply and demand problems and what impact they might have on water resource management in the Syr Darya Basin.

A preliminary construction cost estimate for Kambarata 1 (2002 constant dollars) is at least US $1.163 billion, with an installed capacity of 1,200 megawatts (MW) and annual energy generation of 4,500 gigawatt hours (GWh). The preliminary construction cost estimate for Kambarata 2 (2002 constant dollars) is at least US $280 million with an installed capacity of 400 MW and annual energy generation of 1,260 GWh.

This cursory assessment is based on a limited approach that consists in comparing the economic and financial costs of Kambarata 1 and Kambarata 2 with newly built least-cost thermal electric power alternatives in Kyrgyzstan. For Kambarata 1 the alternative considered is a 1,200 MW gas-fired combined cycle plant, and for Kambarata 2 the alternative is a 400 MW gas turbine plant. The preliminary estimates exclude debt service and interest during construction. The current world-market price for gas was assumed for the thermal alternatives. This simple analysis indicated that Kambarata 1 and Kambarata 2 might be competitive with the thermal alternatives in economic terms under certain assumptions (i.e., financial, market demand and supply issues, regulatory and legal reforms, etc.). The equalizing discount rate is 11% for Kambarata 1 and 15% for Kambarata 2.

The sites of the two projects are on the Naryn River, upstream of existing hydropower projects on the Naryn Cascade in Kyrgyzstan (1,200 MW Toktogul Reservoir and 1,670 MW of run-of-river hydropower plants). In order to assess the potential impacts of the Kambarata Hydropower Projects on the water and electric power systems of Kyrgyzstan and its neighbors, operations studies were made of the Naryn Cascade with and without the two projects for the years 2010 and 2015. These studies also looked at alternative operating regimes for the Toktogul Reservoir under present conditions.

The basic problem for Kyrgyzstan is that it is not recovering the cost of energy from customers, whether it is domestically derived or imported electricity and fuel supplies (gas, mazut, and coal). Therefore, Kyrgyzstan chooses to operate the Naryn Cascade year-round to maximize low cost domestic hydropower supplies, especially during winter electric peak demand periods. This has caused the downstream riparian countries (Kazakhstan and

Uzbekistan) to be concerned over the availability of water from Toktogul Reservoir in the summer. The higher winter water releases cannot be used for irrigated agriculture, and ice jams and manmade structures in the Lower Syr Darya River block the flow of water into the Aral Sea. Therefore, during the winter large volumes of water have been diverted into the Arnasai Depression, damaging land and infrastructure in Uzbekistan and depriving the Syr Darya Delta and Northern Aral Sea of much needed water.

To address this energy and irrigation conflict in the use of water resources, the Syr Darya Basin countries entered into the March 17, 1998 Framework Agreement between Kazakhstan, Kyrgyzstan, and Uzbekistan "On the Use of Water and Energy Resources of the Syr Darya Basin". Tajikistan became a party to this 1998 Framework Agreement on June 19, 1998. The 1998 Framework Agreement provides for winter fuel supplies to be delivered to Kyrgyzstan in return for hydroelectric power in the summer months by the downstream countries through essentially barter trade.

In the study of different operating regimes for Toktogul Reservoir, it was found that none of the operating regimes, even the most extreme "electric power oriented regime", eliminates the need for large imports of fuel supplies and energy under present conditions. If conditions do not rapidly improve by 2005, with no additional capacity in service and with average river flows, Kyrgyzstan will have a net annual energy deficit of about 1,500 GWh, resulting from a winter deficit of 3,900 GWh and a summer surplus of 2,400 GWh. The energy deficits have not reached these levels in the past because of unusually high reservoir water inflows to the reservoir coupled with unsustainable levels of water releases. Hydropower generation has been 30% above sustainable levels. Therefore, it is clear that Kyrgyzstan needs to take quick actions in order to reverse these conditions.

A meeting was held in Bishkek on February 25-26, 2003 to seek the comments of Kyrgyzstan electric power and water management officials on the working draft of the initial assessment. This led to useful suggestions on technical issues and a valuable exchange of views on the regional aspects of the two proposed projects. This initial assessment reflects the findings of the Bishkek meeting.

A similar meeting to discuss the initial assessment working draft was held on May 27, 2003 in Almaty with Kazakhstan electric power and water management officials. In the meeting, the electric power officials observed that the winter electricity demand in south Kazakhstan can, for the next several years, be met from north Kazakhstan, assuming low cost electricity tariffs continue at 1.0 to 1.5 US cents per kilowatt hour (kWh). In contrast, the energy cost of Kambarata 1 would be at least 3.0 cents/kWh. However, the participants took the view that Kambarata 1 and possibly Kambarata 2 should continue to be seen as important elements in the long-term development of the Kyrgyzstan and Kazakhstan electric power systems.

An important discussion in the Almaty meeting was on water resource management issues in the Syr Darya Basin and the study of operating regimes for Toktogul Reservoir. The Kazakhstan representatives described the current problems in the timing and volumes of water deliveries to Kazakhstan in the Lower Syr Darya Basin. It was also noted that recent studies under TWEP show that problems in managing the water resources of the Middle Syr Darya River also contribute to the untimely flows into the Chardara Reservoir. The meeting provided an opportunity to update Kazakhstan water resource management officials on the work USAID is funding in Kyrgyzstan and Uzbekistan on ways to improve water management operational rules and methods.

Following the Almaty meeting, the Kazakhstan officials summarized their conclusions, as follows:

1. "Taking into account that the Kambarata 1 and 2 Hydropower Projects are part of the Naryn Cascade, which has strategic meaning for the utilization of water and energy resources of transboundary rivers in Central Asia, the formation of an international water and energy consortium is recommended to address the following issues:
   - Implementation of a regionally consistent water and energy policy.
   - Preparation of water balances (volume of consumption, accumulation, and releases) for each reservoir of the Naryn / Syr Darya Cascade.
   - Adherence to the earlier agreed-upon water shares for each country of the transboundary Syr Darya River.
   - Development of a feasibility study for joint construction and operation of new hydropower facilities, including the Kambarata 1 and 2 Hydropower Projects.
   - Preparation and implementation of common legislation for all Central Asia countries to ensure a legal basis for joint utilization of water and energy resources of transboundary rivers.
   - Harmonization of prices, taxes, customs, and tariff policies in the joint operation of water facilities.
2. The irrigation mode of the Syr Darya River should be considered in order to optimize power generation by hydropower stations.
3. A detailed feasibility study for the Kambarata 1 and 2 Hydropower Projects should be undertaken, covering all issues.
4. Further consideration of the analyses in this initial assessment should be continued with experts of the relevant parties".

A possible long-term solution studied in this initial assessment is the addition of Kambarata 1 to eliminate the conflict in the operation of the Toktogul Reservoir between the irrigation needs of the downstream countries and the winter energy needs of Kyrgyzstan. Kambarata 2 would add to Kyrgyzstan's summer hydroelectric power surplus that could be exchanged for fuel supply imports, but it would not significantly reduce the winter energy deficit.

However, in the short to medium-term, Kyrgyzstan needs to commit to an electric power development plan to reverse its current conditions, which when implemented would be far less expensive and much more timely than construction of the Kambarata 1 and 2 Hydropower Projects. It is strongly recommended that Kyrgyzstan consider undertaking the following initiatives in the immediate future, to better prepare for the consideration of Kambarata 1 and 2 Hydropower Projects as a long-term solution, when it is economically and financially justified. These initiatives include:

- Operate the Bishkek and Osh CHPs at their full capacity during the winter.
- Rehabilitate and modernize district heat facilities.
- Investigate the feasibility of community-owned and operated small hydropower facilities in towns and villages that aren't receiving reliable electricity (i.e., Jangy Naukat, Toktogul, Kirovka, Arkit, Arslan Bob, etc.).
- Through an addendum to the 1998 Framework Agreement, stabilize long-term imports of winter fuel supplies and electric power in return for exports of summer

hydroelectric power by adopting: (i) Toktogul Reservoir Operating Rules that are more responsive to the water demands of Uzbekistan and Kazakhstan, particularly in years of low water runoff in those countries, and (ii) a multi-year Fuel Supply Delivery Protocol to balance varying electric power generation that has resulted from varying summer water releases from Toktogul Reservoir with a steady fuel supply to Kyrgyzstan.

- Reduce technical and non-technical electric losses from the present level of over 40% to less than 18%.
- Increase billing and collection rates to 95%.
- Conduct a feasibility study on Kyrgyzstan's coal resources as a possible domestic supply source for its thermal power and district heat plants (in the 1980's, over one million tons of coal were mined in Kyrgyzstan, but current production is less than 100,000 tons).
- Increase tariffs to recover costs of electric power and district heating, so that investments can be made to improve the system and supplement export revenues to purchase fuel supplies.
- Create incentives for energy conservation and energy efficiency programs to reduce demand.
- Initiate bilateral and multilateral energy power trade agreements with Central Asia countries to strengthen CAPS as a fully functioning power pool.
- Empower the State Energy Agency to make "independent decisions" in the regulation of the electric power sector, which will allow for cost-based tariffs, an efficient meter-billing-collections system, disconnection policies for non-payment, quality customer service, etc.

USAID has continued to support regional and country-specific water resources management and energy reform projects in Central Asia over the last ten years. Through the NRMP and TWEP, USAID will selectively provide limited technical assistance, training, demonstration models, and public outreach on the following next-step activities that could help in improving water and energy cooperation:

- Loss Reduction Demonstration Model.
- Executive Summaries on Electric Power Regulatory and Market Reforms in Kyrgyzstan, Kazakhstan, and Tajikistan.
- Winterization and Energy Efficiency Models.
- Small Community Hydropower Demonstration Project.
- Toktogul Reservoir Operating Rules.
- Middle Syr Darya Basin Decision Support System.

1. INTRODUCTION

1.1. USAID Central Asia Transboundary Water and Energy Support

The strategy of the United States Agency for International Development (USAID) is to support an improvement in the management of critical natural resources through technical assistance, demonstration models, training, public awareness, and partnership development throughout the region in accordance with its Strategic Objective 1.6., "Improved Management of Natural Resources, including Energy". The Central Asia Natural Resources Management Program (NRMP) is implementing this strategy in partnership with USAID.

The Transboundary Water and Energy Project (TWEP), under the NRMP, supports activities that would help leaders in Central Asia develop and agree on measures to improve water and energy cooperation. TWEP focuses on the Syr Darya Basin where a conflict has arisen between the winter energy needs of Kyrgyzstan, the summer irrigation needs of the downstream riparian countries, and the timing of water flows to the Aral Sea. The Syr Darya Basin is geographically located in Kyrgyzstan, Tajikistan, Uzbekistan, and Kazakhstan (Figure 1).

TWEP supports several measures that could reduce regional water/energy conflicts. For example, in Kyrgyzstan TWEP is helping the electric power sector to reduce winter electricity demand by implementing a technical and non-technical loss reduction demonstration model, which includes the limited installation of electric metering equipment, technical assistance on regulatory reform, public outreach campaigns, and training.

Working with the Kyrgyzstan Joint Stock Company Power Plants, TWEP is developing operating rules for Toktogul Reservoir that would make the operation of the reservoir more responsive to the demands of Uzbekistan and Kazakhstan. The rules would provide the downstream countries with the opportunity to save (or "bank") water in the reservoir during years when other water resources are plentiful, for use in subsequent "dry" years when other water resources are low. The rules would also prevent over-filling or completely emptying the reservoir.

With the River Basin Organization (BVO) Syr Darya a Decision Support System (DSS) for the Middle Syr Darya River is being developed that would help to solve the problem of predicting the water inflow from downstream tributaries for the main growing season, and hence, provide early and accurate notice of water demands on the Toktogul Reservoir. This would allow time for water and energy managers in Uzbekistan and Kazakhstan to plan the use of the basin's total water resources and summer surplus of hydropower. The DSS would allow timely changes in the water allocation plans throughout the growing season.

These TWEP activities and recommendations will lead to more effective water resource and energy management in the Syr Darya Basin. The introduction of these management tools, linked to better data and information sharing and reporting, will serve to diminish friction and conflict between the Syr Darya Basin countries and promote lasting cooperation in water resource and energy management.

TWEP also assesses possible long-term structural solutions for the water and energy issues in the Syr Darya Basin. This cursory assessment focuses on the proposal for the construction of the Kambarata 1 and 2 Hydropower Projects for future consideration.

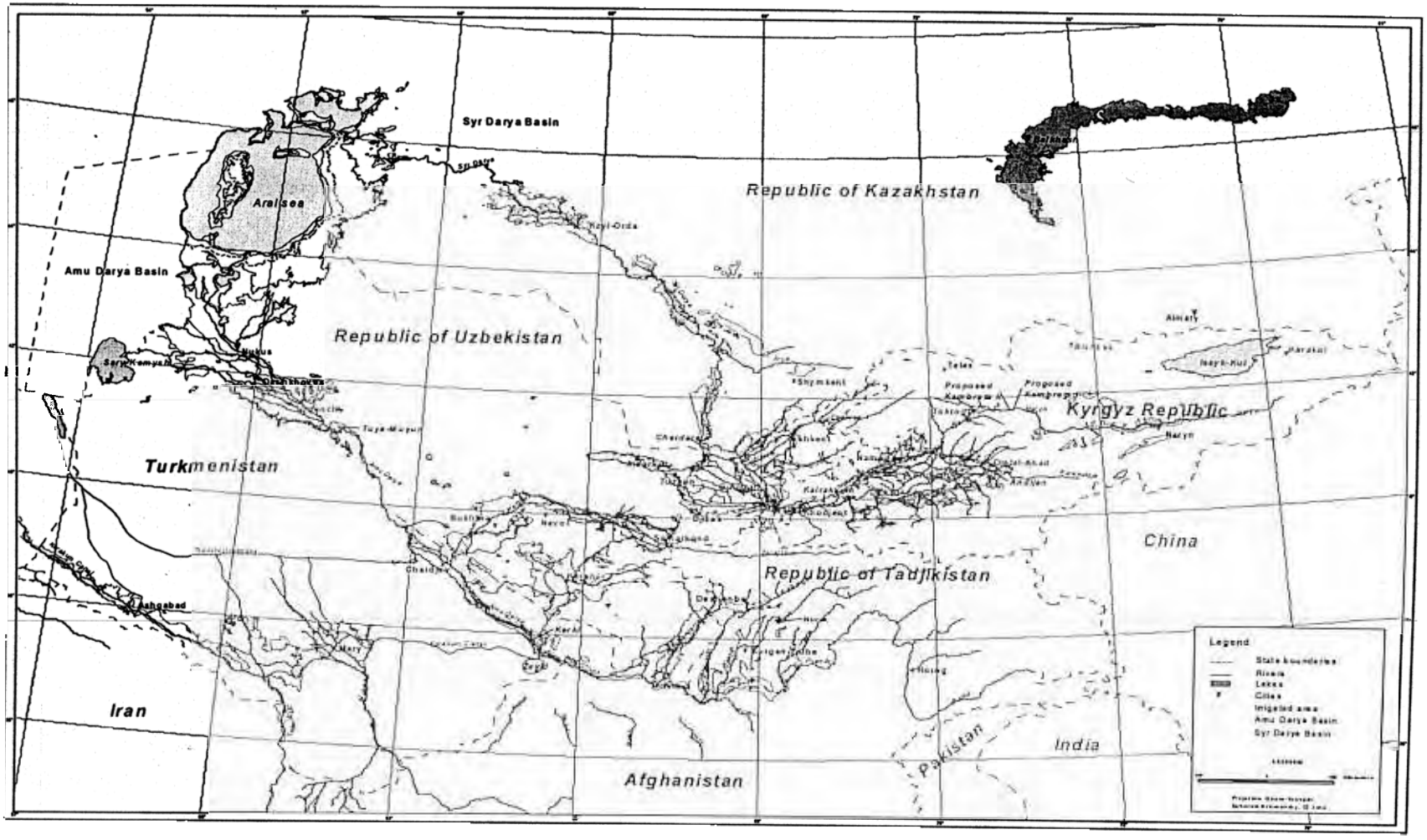

Figure 1. Aral Sea Basin

1.2. Limited Scope and Purpose

The Kambarata 1 and Kambarata 2 Hydropower Projects in Kyrgyzstan were identified under the Soviet regime as logical additions to the integrated Central Asian Power System (CAPS). In 1993 the projects were the subjects of an evaluation study funded by the United States Agency for International Development (USAID) made by Harza Engineering Company. The World Bank and other international financial institutions, donors, and government agencies have expressed continued interest in the variety of linkages between water and electric power in the Aral Sea Basin. In this connection, the two projects have attracted attention as possible long-term alternatives to relieve winter energy shortages in Kyrgyzstan that contributes to water/energy conflicts in the Syr Darya Basin.

This initial assessment of the proposed Kambarata 1 and 2 Hydropower Projects was conducted in response to the continued interest in these projects by the Government of Kyrgyzstan, with the aim of filling in some gaps in the level of knowledge of both projects. The initial assessment has three limited objectives. First, a preliminary review and update of project costs; second, a first-hand glimpse at estimates of energy generation, singly or in combination, when the projects are operated in conjunction with the existing hydroelectric projects on the Naryn Cascade; and third, a comparison of the projects with gas-fired thermal alternatives constructed in Kyrgyzstan.

In the long-term context, data and information in this initial assessment shows the potential contribution of the Kambarata 1 hydropower facility to the Kyrgyzstan power system and the monthly peaking capacity and electric power that would be available for the CAPS. The performance of Kambarata 2 hydropower facility would be primarily as a CAPS peaking power plant.

It should be noted that this initial assessment does not address many of the short to medium-term corrective actions that should be undertaken before the long-term Kambarata 1 and 2 Hydropower Projects can financially and economically be considered. A prerequisite for any new major hydroelectric project in Central Asia will depend on the ability of the Syr Darya Basin countries to:

- Resolve the barriers related to the trade of energy, water, and fuel supplies (gas, mazut, and coal), including equitable pricing and payments based on market controls, sanctity of contracts and compliance, regulatory controls, and allocation policies.
- Upgrade and rehabilitate the water control infrastructure and improve administration and operations of the Syr Darya Basin Water Organization to better manage water resources.
- Introduce legal, regulatory, and institutional reforms of the electric power sector that promote privatization, allow for cost recovery tariffs, reduce energy losses, ensure high billing and collections rates, and provide other essential elements to drive investment in the infrastructure.
- Institute energy efficiency and conservation programs to curtail demand.
- Develop a fully functioning electric power trade market, linking Central Asia and Russia according to demand, supply, and economic dispatch.

- Consider, also, other regional alternatives, prioritized by a least-cost, long-term power expansion plan for the regional market as a whole, such as the proposed 3,000 megawatts (MW) Rogun Hydropower Project in Tajikistan, rehabilitated or new thermal power plants in Kazakhstan and Uzbekistan, and modernization of the Central Asia transmission grid.

Nevertheless, as requested by Kyrgyzstan officials and by design, this initial assessment takes a relatively narrow focus and compares, as the only alternatives, the economic and financial cost of construction and operations of Kambarata 1 and Kambarata 2 Hydropower Projects with least-cost gas-fired power plants to be built in Kyrgyzstan. For Kambarata 1, the alternative is proposed as a 1,200 MW gas-fired combined cycle plant, and for Kambarata 2 the alternative is proposed as a 400 MW gas turbine plant. The preliminary estimates exclude debt service and interest during construction. The current world-market price was assumed for gas purchased by the thermal power plant alternatives.

The data and information presented in this initial assessment documents the growing dependence of Kyrgyzstan on winter fuel and electric power imports. The initial assessment also describes the effect of different operating regimes for the Toktogul Reservoir in an attempt to meet winter electricity demand. In a meeting on the initial assessment conducted with Kyrgyzstan energy and water officials it was explained that their long-term strategy is to reduce their dependence on imports by developing hydropower resources in cooperation with their neighbors. It is Kyrgyzstan's desire to not only meet their own future electric power demand, but to sell low-cost hydropower to the CAPS. The electric power goals of Kyrgyzstan are indeed laudable, but for the short to medium-term many of the corrective actions identified above must be resolved in order to realistically consider the long-term planning and development of the Kambarata 1 and Kambarata 2 Hydropower Projects.

2. THE CENTRAL ASIA POWER SYSTEM

2.1. The Present Situation

The CAPS comprises 85 power stations with an installed capacity of close to 24,450 MW, which 8,960 MW are generated from hydropower plants and 15,400 MW are generated from thermal power plants (Table 2.1). High-voltage, 500 kilovolt (kV), transmission lines link the power systems of the five countries as CAPS in parallel operations and other ancillary services (Figure 2).

Operating capacity is now about 21,000 MW because many of the thermal plants date back to the 1960s and cannot perform at their original capacity. Most of the thermal plants in Uzbekistan and Turkmenistan are conventional gas-fired steam plants. In Kyrgyzstan and Tajikistan the thermal plants are multi-fuel combined heat and power (CHP) plants. The plants in south Kazakhstan are coal-fired and CHP.

The major hydropower plants are located in Kyrgyzstan (including 2870 MW of the Naryn Cascade) and Tajikistan (4,000 MW, including the 3,000 MW plant at the Nurek Reservoir). The main facilities of the CAPS are summarized below in Table 2.1.

Table 2.1 Central Asian Power System Plants and Transmission Lines

Country	Installed Capacity (MW)		
	Thermal	Hydro	Total
Kazakhstan (South)	2,000	360	2,360
Kyrgyzstan			
Tajikistan			
	Transmission Lines (km)		
	500kV	220kV	
Kazakhstan (South)	1,080	1,300	
Kyrgyzstan	541	1,252	
Tajikistan	300	1,200	
Turkmenistan	370	2,000	
	1,700	5,100	
	3,991	10,852	

Under the Soviet regime the CAPS was operated as an integrated electric power pool system under the control of the Unified Dispatch Center (UDC) in Tashkent and responded to regional supply and demand. Surplus energy from the hydropower plants displaced thermal energy in the summer and Kyrgyzstan and Tajikistan imported energy from the thermal plants in the winter. Also, Kyrgyzstan and Tajikistan imported fuel supplies in the winter for their CHP and district heat facilities. In 1990, energy generation reached 112,500 gigawatt-hours (GWh), but then dropped sharply, followed by a slow recovery to 92,000 GWh in 2001 and a peak load of 15,500 MW.

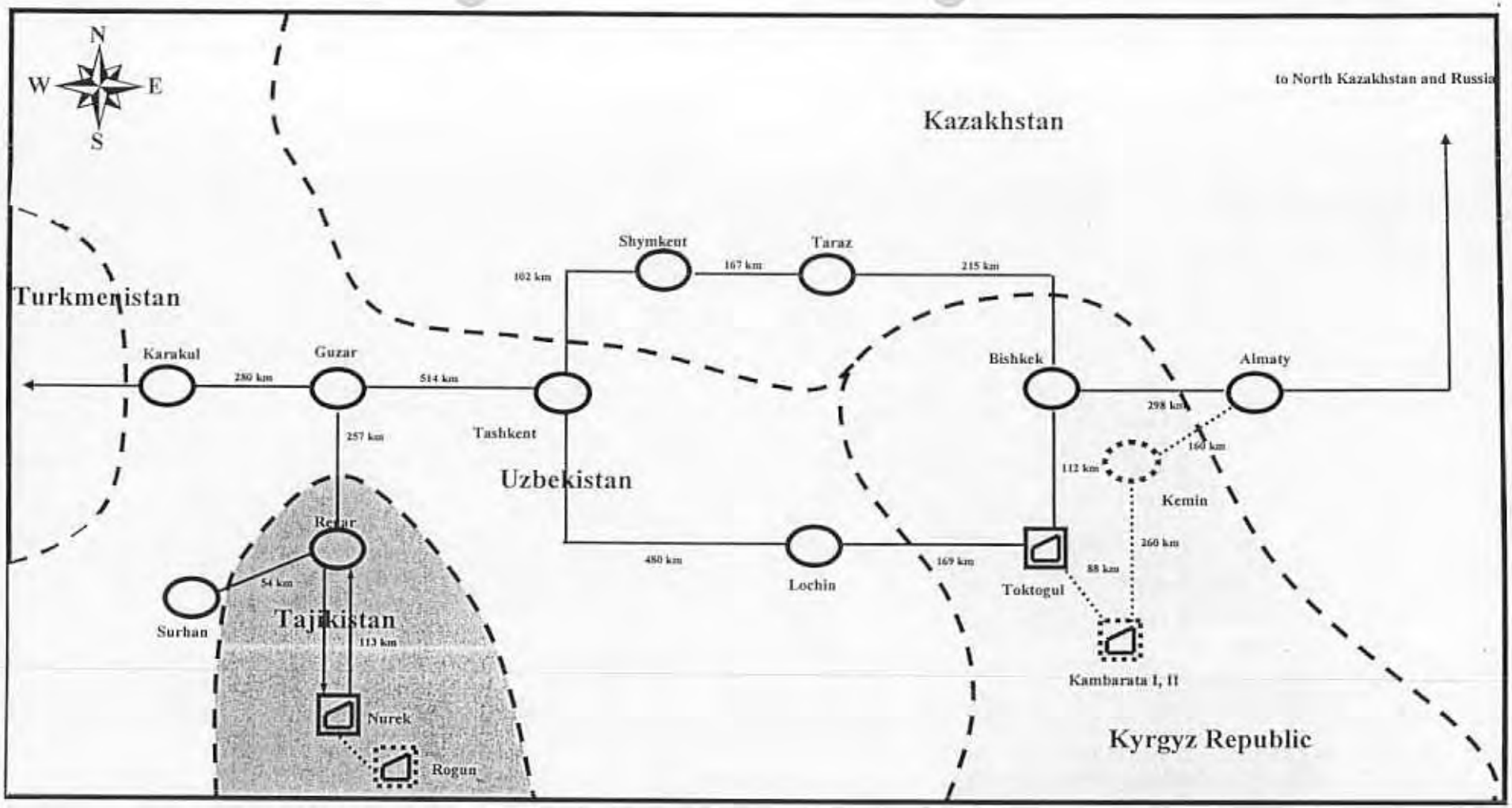

Figure 2. The CAPS Grid

Since independence in 1991, the governments of Central Asia have owned and operated their electric power facilities, with the exception of the ongoing privatization program in Kazakhstan, which began in 1996. In general, fuel supply prices and the costs of generation, transmission, and distribution continue to be well below market and regulatory standards. Low revenues, combined with poor regulation of the electric power sector discourage new investment, which has resulted in a considerable backlog of maintenance, the lack of introduction of new technologies, and cannibalism to replace broken parts. Newly built power projects, either hydropower or thermal, are not viable at the present time or the foreseeable future until market-based and regulatory reforms are reliably implemented.

After independence, the Central Asia countries have operated their generating plants in many ways as five independent power systems. Electric power exchanges still take place through the UDC, but at a lower level than during the Soviet-era. The hydropower plants continue to provide frequency control and system stability to CAPS. Kyrgyzstan still imports fuel supplies in the winter and exports surplus hydropower in the summer under annual agreements with Uzbekistan and Kazakhstan, but the fuel supply deliveries sometimes fall short of Kyrgyzstan's needs and with occasional delays.

Therefore, Kyrgyzstan chooses to operate the Naryn Cascade year-round to maximize low cost domestic hydropower supplies, especially during winter electric peak demand periods. This has caused the downstream riparian countries (Kazakhstan and Uzbekistan) to be concerned over the availability of water from Toktogul Reservoir in the summer. The higher winter water releases cannot be used for irrigated agriculture, and ice jams and manmade structures in the Lower Syr Darya River block the flow of water into the Aral Sea. Therefore, large volumes of water have been diverted into the Arnasai Depression, damaging land and infrastructure in Uzbekistan and depriving the Syr Darya Delta and Northern Aral Sea of much needed water. Before independence, Toktogul Reservoir was primarily operated in the irrigation mode, with the major water releases only during the summer for irrigated agriculture purposes and to prevent overfilling of the reservoir.

To address these problems, in the first half of the 1990s, the Syr Darya Basin countries entered into a number of ad-hoc annual agreements on water and energy exchanges between the upstream and downstream countries in the Syr Darya Basin. In 1997, the governments sought to place these agreements on a more formal footing. USAID provided technical assistance to high level ministerial delegations at various meetings and roundtables that led to the March 17, 1998 Framework Agreement between Kazakhstan, Kyrgyzstan and Uzbekistan, "On the Use of Water and Energy Resources of the Syr Darya Basin". Tajikistan became a party to this 1998 Framework Agreement on June 19, 1998.

The main articles of the 1998 Framework Agreement provide for:

- Annual agreement on the operation of reservoirs of the Naryn-Syr Darya Cascade, the production of hydropower, and the compensation for electricity losses.
- The transfer of energy, in excess of the needs of Kyrgyzstan, in equal amounts to Uzbekistan and Kazakhstan.
- Compensation in equivalent amounts of fuel supplies (coal, gas, mazut) and electricity or in monetary terms as agreed upon for annual and multi-year water storage in upstream reservoirs.

The 1998 Framework Agreement has a five-year validity that is automatically renewed unless any of the parties object. It serves as a basis for preparation of the annual bilateral and multilateral agreements on the use of water and energy resources of the Naryn-Syr Darya Cascade of water reservoirs. The 1998 Framework Agreement is still in effect and takes precedence on the transboundary water and energy issues.

2.2. Potential Benefits in the Greater Integration of CAPS

If the five countries were to integrate their electric power operations with CAPS more fully than at present through strengthened bilateral and multi-lateral trade agreements the following benefits would accrue:

- Greater efficiency in the use of electric power resources by "economic dispatch" (thermal and hydropower plants are coordinated to minimize fuel supply and operating costs) would result in sharing of generation capacity in order to reduce the reserve requirements of the individual systems.
- Better operations of the hydropower plants to provide system stability, frequency control, rapid response peaking, and other ancillary services.
- Energy transfers to Kyrgyzstan and Tajikistan in the winter to supplement fuel supply deliveries.
- Rational use of the hydropower resources to ensure that all reservoir water releases flow through the power plants (no spilling of water).
- A return to Toktogul Reservoir water release patterns (irrigation mode) that accord with downstream-irrigated agriculture demand.

In recent years, the electric power operations in Kazakhstan and Kyrgyzstan have been unbundled into separate generation, transmission, and distribution companies. Economic dispatch is much more plausible with unbundling, however domestic gas prices are highly subsidized in Uzbekistan and Turkmenistan keeping the cost of generation very low and weakening the incentive to import energy in these countries. Therefore, a prerequisite for efficient energy trading is uniform fuel supply pricing and market pricing of electricity.

There are many barriers that need to be resolved to return to a more fully integrated CAPS, including differences in the economic and financial status of the five countries. There is economic sense for Kyrgyzstan and Tajikistan to trade their hydropower in the summer for winter fuel supplies and energy, but this option is further limited by winter energy shortages in Uzbekistan and south Kazakhstan. Nevertheless, limited electric power exchanges continue to be managed by the UDC for a variety of technical reasons, and also to allow the summer hydropower surplus to be absorbed under the 1998 Framework Agreement.

3. THE KYRGYZSTAN POWER SYSTEM

3.1. The Present Situation

The main source of electric power in Kyrgyzstan is the complex of hydropower plants on the Naryn River, known as "the Naryn Cascade". The Naryn River is the main tributary of the Syr Darya River and accounts for 30% of its total runoff (Figure 3). The Naryn Cascade (Figure 4) has an installed capacity of 2,870 MW that consists of the Toktogul Reservoir and its 1,200 MW power plant and four downstream run-of-river plants, Kurpsai (800 MW), Tashkumyr (450 MW), Shamaldysai (240 MW), and Uch-Kurgan (180 MW). Annual energy generation is about 10,600 GWh. There are also smaller hydroelectric facilities in Kyrgyzstan that have a total installed capacity of 70 MW. Appendix A shows the basic data of the existing and planned larger hydropower projects of the Naryn Cascade.

The amount of thermal energy generated is based on imported fuel supplies for the Bishkek (680 MW) and Osh (50 MW) CHPs. These plants are intended to meet the deficit in hydropower in the winter months and supply steam for district heating. Both facilities are old and suffer from deferred maintenance, lack of new technologies, and cannibalism to replace broken parts. It is reported that the monthly energy produced is less than 250 GWh compared to 450 GWh in the Soviet era, which is less than one-third of its installed capacity.

3.2. Electric Power Operations and Water Resource Management

One of the main transboundary water and energy issues in Central Asia is the operation of the Toktogul Reservoir in Kyrgyzstan in the upstream reaches of the Syr Darya Basin. Before 1991, when the Syr Darya Basin was operated as an integrated water and power system, the summer water releases from Toktogul Reservoir averaged 8.1 billion cubic meters (bcm), or 71% of the inflow.

There were two reasons for the Soviet-era irrigation mode-operating regime. First, there was the desire to hold as much water as possible in the reservoir during the winter as a reserve against low summer water inflows. This would ensure that demand for downstream water was met for irrigated agriculture. Second, there was the need to avoid high winter water flows into the Lower Syr Darya River when its capacity is restricted by the poor conditions of man-made structures and ice-jams. Under this irrigation mode-operating regime, fuel supplies for Kyrgyzstan CHP and district heat facilities came from Kazakhstan and Uzbekistan. In addition, electric power was transmitted to Kyrgyzstan through the CAPS power pool, as needed.

The hydropower production in the Naryn Cascade is primarily determined by the outflow of water from the Toktogul Reservoir and in part by the reservoir level. In the past three years the energy generated by Naryn Cascade was 11,906 GWh (1999), 13,414 GWh (2000) and 12,137 GWh (2001). In these years, water inflow to Toktogul Reservoir was above the long-term average of 12.0 bcm by 25% in 1999, 9% in 2000, and 9% in 2001. In 1999, the volume of water in the Toktogul Reservoir was increased by 0.9 bcm to 14.5 bcm by the end of the summer, but in 2000 and 2001 the reservoir was depleted in order to enhance the energy output of the Naryn Cascade. This process was continued in early 2002, with the reservoir being depleted to a volume of less than 8.0 bcm. The reservoir recovered in the summer of 2002, due to ample water inflow and also reduced water releases at the request of the downstream riparian countries.

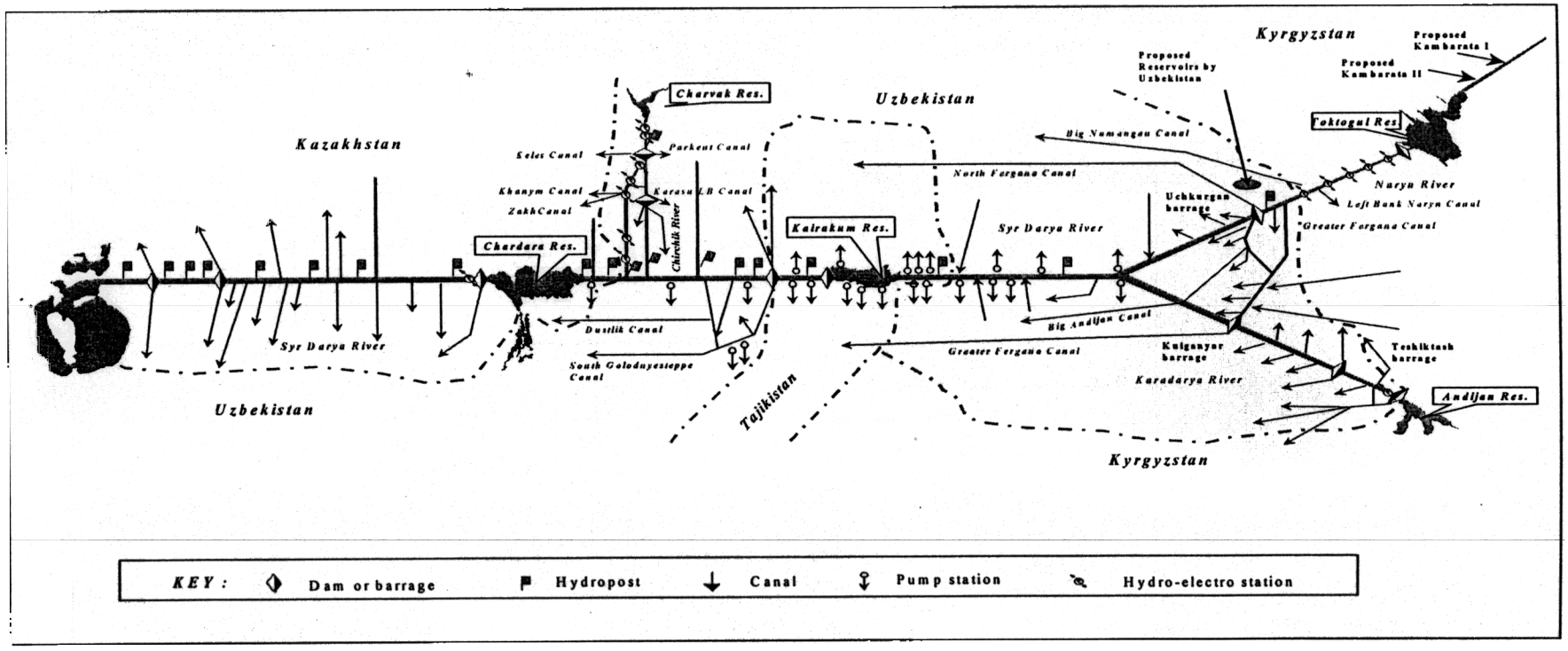

Figure 3. Water and Hydropower Facilities of the Syr Darya Basin

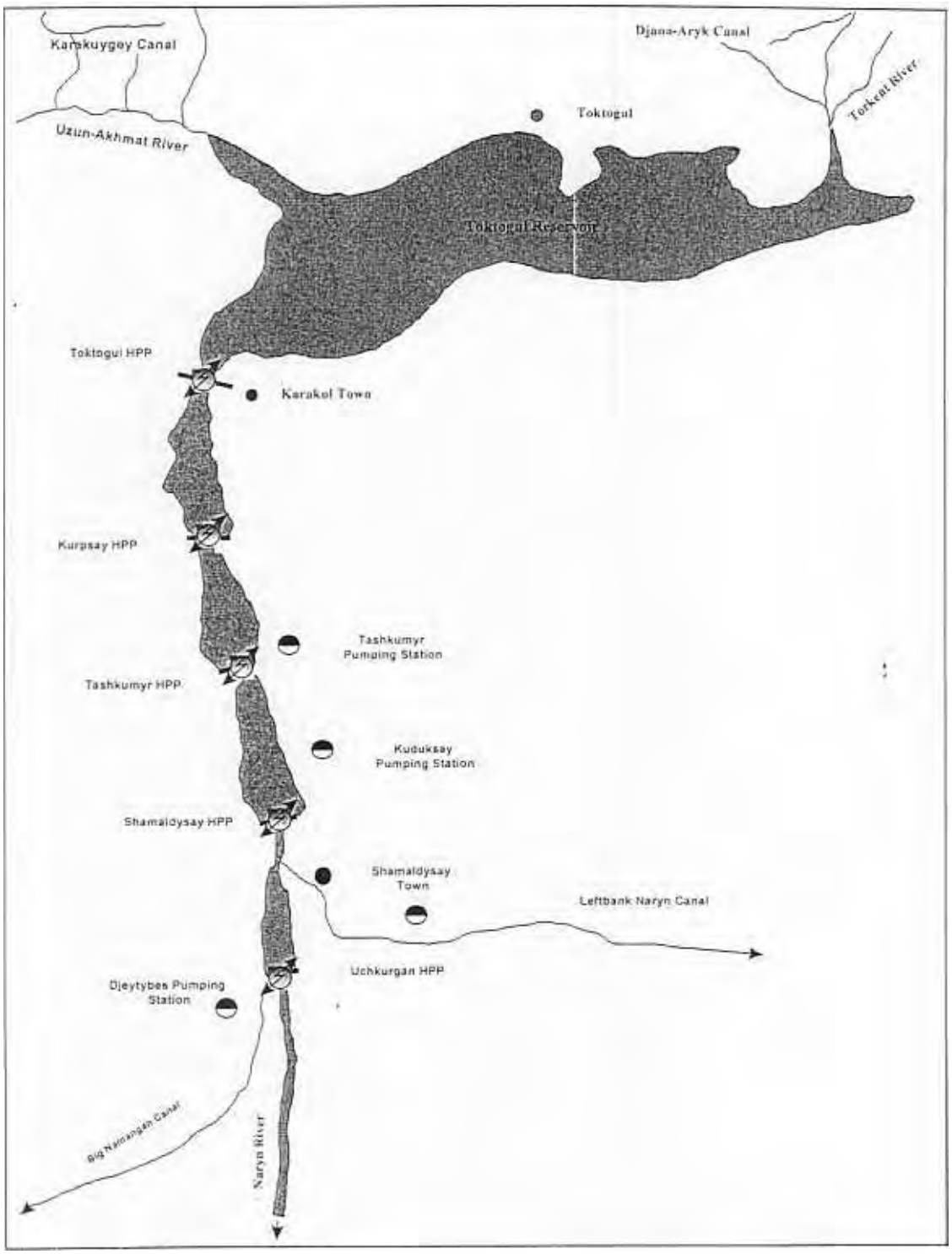

Figure 4. The Naryn Cascade

Since independence, the energy demand patterns of Kyrgyzstan have changed drastically and Kyrgyzstan now faces much higher winter electric power demands than in the past, due to a sharp rise in the use of electricity for residential heating. This rise in demand is based on several factors, including not enough fuel supplies for the full operation of CHP and district heat plants. Additionally, very low electric power tariffs and the general disregard of other regulatory concerns plagues the State Energy Agency (SEA). These factors do not provide incentives for energy conservation and efficiency measures, leading to additional stress on the electric power system.

To meet the high winter demand for electricity, the operation mode of the Toktogul Reservoir was switched from irrigation to primarily electric power generation, which requires major water releases during winter when electric power demand is highest. As a result, the winter releases from the reservoir increased from an average 2.7 bcm before 1991 to an average 7.2 bcm since 1991 (or from 24% of average reservoir water inflow before 1991 to 56% of average water inflow after 1991).

The sharp increase in winter water releases has created problems for the downstream riparian countries. Winter inflows to the Chardara Reservoir (in Kazakhstan) have risen by 30%, with occasional spills occurring into the nearby Arnasai Depression (in Uzbekistan). But the Lower Syr Darya River does not have enough capacity in the winter to transport surplus flows to the Northern Aral Sea; in part this is because of the poor condition of man-made structures on the river and the formation of ice-jams. In the 1980s, there was only one water spill from Chardara Reservoir into the Arnasai Depression, but since 1992 annual water spills have accumulated 30 bcm in the Depression. This has damaged land and infrastructure in Uzbekistan and deprived the Syr Darya Delta and the Northern Aral Sea of much-needed water.

The corresponding reduction in summer water releases from the Toktogul Reservoir contributed to shortages of water during demand periods for irrigated agriculture in Uzbekistan and the reduction of irrigated areas in Kazakhstan. Since 1991, the summer water releases from Toktogul Reservoir have averaged 6.0 bcm, only 46% of the inflow. The impacts of the decline in summer water releases on irrigated agriculture have been mitigated to some extent because farmers have switched some of their land from summer crops to winter wheat (planted in October and harvested in May/June). However, this change in the cropping pattern is believed to be mainly for economic reasons rather than a water shortage.

In 1998, high tributary flows greatly reduced the water demand in the Syr Darya Basin and Toktogul Reservoir water releases were held to 3.8 bcm in the summer by mutual agreement. But, since then, the summer water releases have been close to 6.0 bcm. Under the 1998 Framework Agreement the annual agreed-upon needs of fuel supplies have been, for the most part, delivered to Kyrgyzstan as required, albeit with occasional delays and less than actual winter demand dictates. Data for the deliveries of fuel supplies for the winter of 2001/2002 were in line with agreements reached in mid-2001. Nevertheless, there is still a shortage of fuel supplies for winter electricity generation and district heat in Kyrgyzstan. Downstream countries still report water irrigation shortages in the summer and water losses in the Arnasai Depression remain high in the winter.

To balance its shortage of fuel supplies for winter energy generation, Kyrgyzstan has had to increase water releases and hydropower generation from Toktogul Reservoir in the winter. In recent years, annual water releases from the reservoir have substantially exceeded annual

water inflows, despite substantially higher than average inflows of water into the Toktogul Reservoir.

3.3. Electricity Load Forecast

After independence, the demand patterns and the fuel-energy balance of Kyrgyzstan has changed drastically. Due to complications in Central Asia intergovernmental relations and account settlements; introduction of non-convertible national currencies; and rising prices of fuel supplies and their corresponding transportation costs, fuel supplies imported to Kyrgyzstan were reduced. The loss of foreign markets for most of Kyrgyzstan's exports caused a sharp drop in the electricity demand of the industrial and agriculture sectors, while at the same time winter demand for electricity (primarily for residential heat) has dramatically increased.

The dramatic redistribution of demand among customers and the corresponding growth in electricity losses within the last ten years is illustrated in Table 3.1. This table is based on data provided by the SEA. What stands out is the increasing level of technical and non-technical electricity losses. In 2001, electricity losses of 42% of gross consumption (generation plus imports minus exports) were reported.

Table 3.1 Electricity Demand by Customer Group

Customer Group	Demand (GWh)			
	1991	1999	2000	2001
Industry	3,509	1,531	1,369	1,286
Commercial	1,178	1,262	1,365	1,551
Agriculture	1,986	656	586	508
Residential	1,455	3,802	4,455	3,179
Electricity Losses	1,064	3,740	3,839	4,806
Gross Consumption	9,192	11,222	11,876	11,572

The growth in gross consumption of electricity in recent years is largely due to the higher level of electricity losses. Monthly generation, imports, and exports of electricity for 1999 – 2001 is found in Appendix B. It can be seen that January energy demand is more than three times the demand in the summer months and percentage losses in the winter are much higher than in the summer.

As a result, the system electricity load factor is very high in the winter months (over 80%). This is typical of an electric power system where demand is limited by supply. Tariffs are low, less than 1.0 US cent per kilowatt-hour (kWh) and collection rates are poor. The resulting low revenues, which are unable to support electricity costs, and Kyrgyzstan's low foreign exchange earnings limit the ability to purchase fuel supplies (in addition to what Kyrgyzstan imports from the downstream countries through the 1998 Framework Agreement). Therefore, Kyrgyzstan cannot meet demands for winter heating from their CHPs and district heat facilities.

Kyrgyzstan depends on most of its energy from the seasonal output of its hydropower plants, which varies from month-to-month according to water releases from the Toktogul Reservoir. Therefore, an electricity load forecast has to estimate the monthly as well as the annual demands. Also, the effect of electric loss-reduction programs (as recommended in the September 23, 2002 TWEP report "Support to Electricity Loss Reduction in Kyrgyzstan")

has to be taken into account. The greatest factors that limit electricity load growth are the enforcement of higher cost-based tariffs and corresponding collection rates and the introduction of energy conservation standards. These implementation of these factors falls under the auspices of the SEA.

In 2000, end-use customers purchased 7,800 GWh of electricity. The losses of 3,800 GWh in that year can be assumed to include 50% (1,900 GWh) of electricity that was used, but not purchased. Thus, the actual customer end-use was approximately 9,700 GWh. For the purposes of this initial assessment, the demand by 2010 and 2015 assumes 1.3% annual growth in electricity consumption, electric losses of 18%, and a winter/summer demand ratio declining from 3.2 to 2.0. System electricity load factors are assumed to be 65% in the winter and 55% in the summer. Until 2005, assumptions are that the effect of electric loss reduction and higher tariffs will be minimal at best and it is assumed that total electricity consumption grows at one percent annually. These assumptions lead to the electricity load forecasts presented in Appendix C. It should be noted that the findings of this initial assessment are not particularly sensitive to the electricity load forecasts.

3.4. Naryn Cascade Operation Study

The hydropower produced by the Naryn Cascade in 1999 - 2001 was much higher than the long-term average. In those years, the water outflows were 13.1 bcm (1999), 14.8 bcm (2000), and 13.8 bcm (2001). Over the long term, the water outflow should not normally exceed the average water inflow of 12.0 bcm and this would produce on average about 10,700 GWh compared to the average for the last three years of 12,500 GWh. Therefore, the objectives of the following Naryn Cascade Operation Study are to examine, under conditions of average annual reservoir water inflow, the effect of different operating regimes on: (a) annual and seasonal energy shortages and the need for fuel supplies and energy imports, and (b) the peak monthly winter energy deficit. There are basically three operating regimes that could be adopted at Toktogul Reservoir for the Naryn Cascade:

- T65 - This regime is similar to the Soviet era situation, when the summer water outflow from Toktogul Reservoir was about 65% of the annual water inflow (7.8 bcm).
- T55 - This regime is more or less similar to the present situation when a summer water outflow of 6.5 bcm is maintained, which is 55% of the average annual water inflow.
- T22 - This regime would concentrate most of the water outflow in the winter months so that the summer water outflow is only 2.7 bcm, which is 22% of the average annual water inflow.

A monthly operation study was run for the Toktogul Reservoir for an average water flow year (12.0 bcm) for each of these regimes. It is assumed that 250 GWh is available in any month from the existing thermal plants. Demands are estimated for 2005 at 5% higher than 2000. The calculations and results of the Naryn Cascade Operation Study are presented in Appendix D and summarized in Table 3.2 below.

APPENDIX A: BASIC DATA OF THE EXISTING AND PLANNED LARGER HYDROPOWER PROJECTS OF THE NARYN CASCADE

Toktogul

Pool Level	Gross Reservoir Capacity mcm V	Head m H	GWh/mcm	MW
900	19,400	176	0.421	1200
890	17,000	164	0.394	1123
880	14,800	154	0.369	1052
870	12,500	143	0.343	977
860	10,400	133	0.319	910
850	8,000	122	0.292	832
840	6,000	112	0.269	768

H= 85+(V/212)
Gwh/mcm=H*2724*0.88/10^6

Kambarata 1 (planned)

Pool Level	Gross Recervoir Capacity mcm V	Head m H	GWh/mcm	MW
1200	5080	242		
1190	4,500	233	0.560	2000
1150	2,680	192	0.459	1645
1100	1,220	141	0.339	1213

H=87.8+48.12V-3.5V^2
Gwh/mcm=H*2724*0.88/10^6

Kambarata 2 (planned) Average head 50 m , Gwh/mcm=0.120 350 MW

Kurpsai Average head 92 m , Gwh/mcm=0.221 800 MW

Tashkumyr Average head 53 m , Gwh/mcm=0.127 450 MW

Shamaldysai Average head 26 m , Gwh/mcm=0.062 240 MW

Uch-Kurgan Average head 29 m , Gwh/mcm=0.070 180 MW

APPENDIX B: MONTHLY GENERATION, IMPORTS AND EXPORTS OF ELECTRICITY FOR 1999 - 2001

YEAR 1999	Totals	Jan	Feb	March	April	May	June	July	August	Sept	Oct	Nov	Dec
Total Generation	**13,119**	**1,641**	**1,327**	**1,400**	**999**	**664**	**662**	**1,093**	**1,021**	**536**	**804**	**1,356**	**1,616**
Thermal	**982**	**197**	**158**	**157**	**62**	**28**	**15**	**14**	**14**	**28**	**53**	**107**	**150**
Hydro	**12,138**	**1,444**	**1,169**	**1,243**	**937**	**637**	**647**	**1,079**	**1,008**	**508**	**750**	**1,250**	**1,466**
Toktogul	4,991	629	493	514	371	198	226	423	425	199	316	554	644
Kurpsai	3,353	409	333	363	266	187	176	289	270	133	199	334	394
Tashkumyr	1,918	210	175	192	149	123	119	184	160	83	116	189	218
Shamaldysai	685	67	56	64	56	46	48	70	61	32	41	61	83
UchKurgan	959	110	95	94	82	61	57	85	73	36	57	96	114
Small Hydro	54	10	9	7	5	3	2	3	3	6	3	2	1
Small Hydro	50	2	2	1		6	6	7	7	7	7	4	2
Small Hydro	127	7	8	6	7	13	14	19	10	13	11	10	10
TPBishkek	918	179	142	145	62	28	15	14	14	28	53	103	136
TP Osh	64	18	16	12	0	0	0	0	0	0	0	4	15
Import	**4**	**0**	**1**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**0**
Tajikistan	185	0	0	0	0	23	58	32	28	43	0	0	2
Uzbekistan	138	0	0	0	0	14	26	27	28	43			0
Kazakhstan	2	0	0	0	0	0	0	0	0	0			2
Turkmenistan	46	0	0	0	0	9	32	5	0	0			0
	49	0	0	0	0	0	0	0	0	0	49		0
Export	**1,999**	**15**	**18**	**72**	**105**	**67**	**196**	**596**	**516**	**62**	**143**	**141**	**69**
Uzbekistan	970	2	0	0	0	21	148	413	387	0		0	0
Kazakhstan	880	14	12	15	19	46	48	184	128	62	143	141	69
Tajikistan	149	0	6	57	86	0	0	0	0	0			0
China	0					0	0	0	0	0			
Losses in Kazakhstan	136	11	8	10	13	12	9	0	5	8	13	20	27
Gross Consumption	**11,222**	**1,614**	**1,302**	**1,318**	**882**	**609**	**516**	**529**	**529**	**509**	**697**	**1,196**	**1,522**
.	0												
	0												
Station Use	190	30	26	28	13	8	6	5	5		12	21	29
System Use	42	10	9	7	1	0	0	0	0		1	2	9
	0												
	3,739	686			255	68	1(						
	7,252	888			612	34	4(						

YEAR 2000	Totals	Jan	Feb	March	April	May	June	July	August	Sept	Oct	Nov	Dec
Total Generation	**14,862**	**1,737**	**1,633**	**1,413**	**847**	**932**	**1,098**	**1,422**	**1,263**	**613**	**1,040**	**1,301**	**1,562**
Thermal	**1,210**	**157**	**151**	**118**	**47**	**23**	**34**	**44**	**44**	**52**	**80**	**203**	**256**
Hydro	**13,652**	**1,580**	**1,482**	**1,295**	**800**	**909**	**1,064**	**1,379**	**1,219**	**561**	**960**	**1,098**	**1,306**
Toktogul	5,580	689	628	522	295	331	422.1	572	510	224	388	454	545
Kurpsai	3,719	430	410	358	217	242	286.6	377	335	152	260	298	354
UchKurgan	1,061	120	116	100	69	77	82.1	102	88	39	77	86	106
Tashkumyr	2,157	234	224	202	145	163	173.9	212	188	90	154	172	200
Shamaldysai	897	89	86	79	59	69	74.2	91	81	38	66	77	90
Small Hydro	25	7	8	4	1	3	2.4	0	0	0	0	0	0
Small Hydro	52	2	2	3	4	7	6.5	7	7	7	3	2	2
Small Hydro	161	10	8	27	11	17	16.2	18	10	12	13	10	9
TPBishkek	1,164	144	145	118	47	23	34	44	44	52	79	192	240
TP Osh	46	12	6	0	0	0	0	0	0	0	1	11	16
Import	**320**	**0**	**0**	**0**	**0**	**19**	**67**	**39**	**0**	**45**	**33**	**22**	**95**
Tajikistan	126	0	0	0	0	19	67	39	0	0	0	0	0
Uzbekistan	195	0	0	0	0	0	0	0	0	45	33	22	95
Kazakhstan	0	0	0	0	0	0	0	0	0	0	0	0	0
Turkmenistan	0	0	0	0	0	0	0	0	0	0	0	0	0
Export	**3,153**	**103**	**56**	**52**	**117**	**368**	**614**	**907**	**722**	**132**	**75**	**3**	**5**
Uzbekistan	1,926	0	2	0	0	289	441	678	516	0	0	0	0
Kazakhstan	1,073	103	52	24	9	63	173	229	205	132	75	3	5
Tajikistan	154	0	2	28	108	17	0	0	0	0	0	0	0
China	0	0	0	0	0	0	0	0	0	0	0	0	0
Losses in Kazakhstan	179	28	27	22	8	8	6	6	6	7	17	19	24
Gross Consumption	**11,876**	**1,606**	**1,550**	**1,322**	**722**	**576**	**546**	**553**	**542**	**525**	**990**	**1,310**	**1,636**
	0												
	0												
Station Use	214	30	27	24	11	7	8	9	9	10	15	29	35
System Use	44	10	9	6	1	0	0	1		1	3	4	9
	0												
Losses	3,839	684	660	555	205	118	109	95	85	80	296	406	546
Sales	7,779	882	854	738	506	451	428	447	447	434	676	871	1045

YEAR 2001	Totals	Jan	Feb	March	April	May	June	July	August	Sept	Oct	Nov	Dec
Generation	**13,553**	**1,666**	**1,553**	**1,265**	**845**	**682**	**955**	**1,286**	**1,075**	**705**	**870**	**1,039**	**1,612**
Hydro	**12,337**	**1,410**	**1,406**	**1,148**	**789**	**646**	**916**	**1,246**	**1,038**	**637**	**772**	**903**	**1,426**
Thermal	**1,215**	**256**	**146**	**117**	**56**	**36**	**39**	**40**	**37**	**67**	**98**	**136**	**186**
Toktogul	4,787	565	556	431	277	211	347	506	417	247	301	357	571
Kurpsay	3,457	397	404	330	226	176	251	350	291	172	214	247	399
Uch-Kurgan	973	118	115	99	64	57	70	81	72	46	61	74	116
Tashkumyr	2,006	220	222	191	143	121	153	200	165	104	121	142	224
Shamaldy-Say	915	99	100	85	66	56	71	92	77	47	55	66	102
Kemin	50	2	2	3	4	7	6	7	7	6	3	2	2
At-Bashy	150	8	8	10	11	18	17	11	10	16	16	14	12
Bishkek TPP	1,166	241	135	110	56	36	39	40	37	67	98	136	171
Osh TPP	49	15	12	8	0	0	0	0	0	0	0	0	15
Import	**322**	**63**	**5**	**0**	**0**	**0**	**0**	**16**	**16**	**3**	**50**	**123**	**46**
Tajikistan	35	0	0	0	0	0	0	16	16	3	0	0	0
Uzbekistan	287	63	5	0	0	0	0	0	0	0	50	123	46
Kazakhstan	0	0	0	0	0	0	0	0	0	0	0	0	0
Turkmenistan	0	0	0	0	0	0	0	0	0	0	0	0	0
Export	**2,165**	**10**	**13**	**45**	**44**	**87**	**419**	**739**	**567**	**160**	**68**	**12**	**1**
Uzbekistan	1,038	0	0	0	0	48	245	458	287	0	0	0	0
Kazakhstan	1,049	10	9	4	11	39	175	282	280	160	68	11	1
Tajikistan	78	0	4	41	33	0	0	0	0	0	0	0	0
China	0	0	0	0	0	0	0	0	0	0	0	0	0
Losses in Kazakhstan	170	23	28	20	12	8	6	5	7	6	11	17	28
Gross Consumption	**11,572**	**1,700**	**1,522**	**1,196**	**786**	**592**	**531**	**562**	**522**	**546**	**850**	**1,135**	**1,630**
Station Use	219	36	28	22	11	8	8	10	10	11	16	25	34
System Use	22	7	8	5	1	0	0	0	0	0	0	0	0
Losses	4,806	813	652	445	252	171	152	169	148	150	382	533	939
Sales	6,525	844	833	724	522	412	371	383	364	385	452	577	658

APPENDIX C: ELECTRICITY LOAD FORECASTS

Year	Totals	J	F	M	A	M	J	J	A	S	O	N	D
2000 Gross Consumption GWh	11,876	1,606	1,550	1,322	722	576	546	553	542	525	990	1,310	1,636
2005 EnergyDemand GWh	12,482	1,688	1,629	1,389	759	605	574	581	570	552	1,040	1,377	1,719
System Load Factor %		80	80	70	65	65	65	65	65	65	70	75	80
2005 Peak Demand		2,890	2,789	2,719	1,599	1,276	1,209	1,225	1,201	1,163	2,036	2,515	2,944
2000 End Use GWh	**9,700**												
2010 End Use GWh	**11,037**												
2015 End Use GWh	**11,774**												
Monthly Distribution (%)		11.4	11.4	10.1	8.1	5.9	5.7	5.7	5.7	5.8	8.8	10.0	11.4
System Load Factor (%)		65	65	65	55	55	55	55	55	55	65	65	65
2010 Energy Demand GWh	**13,024**	1,485	1,485	1,315	1,055	768	742	742	742	755	1,146	1,302	1,485
2010 Peak Demand (MW)		3,129	3,129	2,772	2,628	1,914	1,849	1,849	1,849	1,881	2,415	2,745	3,129
2015 Energy Demand GWh	**13,893**	1,584	1,584	1,403	1,125	820	792	792	792	806	1,223	1,389	1,584
2015 Peak Demand (MW)		3,338	3,338	2,957	2,372	1,727	1,669	1,669	1,669	1,698	2,577	2,928	3,338

Assumptions:

1. **2005 Energy Demand assumes 1% annual growth in gross consumption.**
2. **Year 2000 end use is 2000 sales of 7,800 GWh plus 1,900 GWh (50% of losses) (see Annex A).**
3. **For 2010 and 2015, Annual growth in end use is 1,3 %.**
4. **Technical Losses: 18%,**
5. **Monthly energy distribution and system load factors as shown. See Annex B (Page 2) for 2000 load factors.**

APPENDIX D: CALCULATIONS AND RESULTS OF THE NARYN CASCADE OPERATION STUDY

Toktogul Operating Regime T 22 (Summer 22%, 2,700 mcm)

	J	F	M	A	M	J	J	A	S	O	N	D			
Toktogul															
Inflow mcm	401	355	405	688	1,554	2,480	2,280	1,439	790	684	512	434	12,022		
Outflow mcm	1,700	1,700	1,611	700	400	400	400	400	400	1,200	1,500	1,611	12,022		
Reservoir BOM	16,888	15,589	14,244	13,038	13,026	14,180	16,260	18,140	19,179	19,500	18,984	17,996			
Reservoir EOM	15,589	14,244	13,038	13,026	14,180	16,260	18,140	19,179	19,400	18,984	17,996	16,819			
Avg. Reservoir Content	16,239	14,917	13,641	13,032	13,603	15,220	17,200	18,660	19,290	19,242	18,490	17,408			
Head	161	154	148	145	148	156	165	172	175	175	171	166			
GWh/mcm	0.385	0.370	0.356	0.349	0.355	0.373	0.396	0.412	0.419	0.419	0.410	0.398			
MW	999	918	839	802	837	937	1,058	1,148	1,187	1,184	1,138	1,071			
GWh	654	629	573	244	142	149	158	165	168	503	616	641	4,643		
											Summer		2,700		
Kurpsai															
Inflow mcm	1,700	1,700	1,611	700	400	400	400	400	400	1,200	1,500	1,611	12,022		
GWh/mcm	0.221	0.221	0.221	0.221	0.221	0.221	0.221	0.221	0.221	0.221	0.221	0.221			
MW	800	800	800	800	800	800	800	800	800	800	800	800			
GWh	376	376	356	155	88	88	88	88	88	265	332	356	2,657		
Tributary Inflow mcm	50	45	71	181	262	211	131	76	55	52	52	44	1,230		
Tashumyr															
Inflow mcm	1,750	1,745	1,682	881	662	611	531	476	455	1,252	1,552	1,655	13,252		
GWh/mcm	0.127	0.127	0.127	0.127	0.127	0.127	0.127	0.127	0.127	0.127	0.127	0.127			
MW	450	450	450	450	450	450	450	450	450	450	450	450			
GWh	222	222	214	112	84	78	67	60	58	159	197	210	1,683		
Shamaldysai															
Inflow mcm	1,750	1,745	1,682	881	662	611	531	476	455	1,252	1,552	1,655	13,252		
GWh/mcm	0.062	0.062	0.062	0.062	0.062	0.062	0.062	0.062	0.062	0.062	0.062	0.062			
MW	240	240	240	240	240	240	240	240	240	240	240	240			
GWh	109	108	104	55	41	38	33	30	28	78	96	103	822		
Uch Kurgan															
Inflow mcm	1,750	1,745	1,682	881	662	611	531	476	455	1,252	1,552	1,655	13,252		
GWh/mcm	0.070	0.070	0.070	0.070	0.070	0.070	0.070	0.070	0.070	0.070	0.070	0.070			
MW	180	180	180	180	180	180	180	180	180	180	180	180			
GWh	123	122	118	62	46	43	37	33	32	88	109	116	928		
														Winter	Summer
Total Hydro GWh	1,483	1,457	1,365	627	402	396	384	377	374	1,092	1,349	1,426	10,732	8,172	2,560
Total Hydro Capacity MW	2,669	2,588	2,509	2,472	2,507	2,607	2,728	2,818	2,857	2,854	2,808	2,741			15,989
															0
2005 Energy Balance															0
KYG Energy Demand	1,688	1,629	1,389	759	605	574	581	570	552	1,040	1,377	1,719	12,484	8,843	3,641
Hydro Surplus	0	0	0	0	0	0	0	0	0	52	0	0	0	0	0
Energy Deficit	205	172	25	132	203	178	197	193	178	0	28	293	1,804	723	1,081
Supplied by Fuel Imports	205	172	25	132	203	178	197	193	178		28	250	1,760	680	1,081
Supplied by Energy Imports	0	0	0	0	0	0	0	0	0	0	0	43	43	43	0
Annual Defict													1,804	723	1,081
2005 Capacity Balance															
KYG Peak Demand 2005 MW	2,890	2,789	2,719	1,599	276	1,209	225	1,201	1,163	2,036	2,515	2,944			
Surplus Capacity	-221	-202	-210	873	231	1,397	504	1,618	1,694	818	293	-203			

APPENDIX D: CALCULATIONS AND RESULTS OF THE NARYN CASCADE OPERATION STUDY

Toktogul Operating Regime T 55 (Summer 55%, 6,500 mcm)

	J	F	M	A	M	J	J	A	S	O	N	D			
Toktogul															
Inflow mcm	401	355	405	688	1554	2480	2280	1439	790	684	512	434	12,022		
Outflow mcm	855	1005	1055	900	1000	1300	1400	1300	600	698	905	1004	12,022		
Reservoir BOM	18,503	18,049	17,399	16,749	16,537	17,091	18,271	19,151	19,290	19,400	19,386	18,993			
Reservoir EOM	18,049	17,399	16,749	16,537	17,091	18,271	19,151	19,290	19,400	19,386	18,993	18,423			
Avg. Reservoir Content	18,276	17,724	17,074	16,643	16,814	17,681	18,711	19,221	19,345	19,393	19,190	18,708			
Head	170	168	165	163	163	167	172	175	175	175	175	172			
Gwh/mcm	0.408	0.402	0.394	0.390	0.391	0.401	0.413	0.419	0.420	0.421	0.418	0.413			
MW	1125	1091	1051	1024	1035	1088	1151	1183	1190	1193	1181	1151			
Gwh	349	404	416	351	391	522	578	544	252	294	379	415	4,894		
											Summer		6,500		
Kurpsai															
Inflow mcm	855	1005	1055	900	1000	1300	1400	1300	600	698	905	1004	12,022		
Gwh/mcm	0.221	0.221	0.221	0.221	0.221	0.221	0.221	0.221	0.221	0.221	0.221	0.221			
MW	800	800	800	800	800	800	800	800	800	800	800	800			
Gwh	189	222	233	199	221	287	309	287	133	154	200	222	2,657		
Tributary Inflow mcm	50	45	71	181	262	211	131	76	55	52	52	44	1,230		
Tashkumyr															
Inflow mcm	905	1050	1126	1081	1262	1511	1531	1376	655	750	957	1048	13,252		
Gwh/mcm	0.127	0.127	0.127	0.127	0.127	0.127	0.127	0.127	0.127	0.127	0.127	0.127			
MW	450	450	450	450	450	450	450	450	450	450	450	450			
Gwh	115	133	143	137	160	192	194	175	83	95	122	133	1,683		
Shamaldysai															
Inflow mcm	905	1050	1126	1081	1262	1511	1531	1376	655	750	957	1048	13,252		
Gwh/mcm	0.062	0.062	0.062	0.062	0.062	0.062	0.062	0.062	0.062	0.062	0.062	0.062			
MW	240	240	240	240	240	240	240	240	240	240	240	240			
Gwh	56	65	70	67	78	94	95	85	41	47	59	65	822		
Uch Kurgan															
Inflow mcm	905	1050	1126	1081	1262	1511	1531	1376	655	750	957	1048	13,252		
Gwh/mcm	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07			
MW	180	180	180	180	180	180	180	180	180	180	180	180			
Gwh	63	74	79	76	88	106	107	96	46	53	67	73	928		
														Winter	Summer
Total Hydro Gwh	772	898	941	829	939	1200	1284	1188	554	642	826	908	10,983	4,987	5,995
Total Hydro Capacity	2795	2761	2721	2694	2705	2758	2821	2853	2860	2863	2851	2821			
2005 Energy Balance															
KYG Energy Demand	1,688	1,629	1,389	759	605	574	581	570	552	1,040	1,377	1,719	12,484	8,843	3,641
Hydro Surplus	0	0	0	71	334	626	703	618	3	0	0	0	2,355	0	2,355
Energy Defict:	916	731	449	0	0	0	0	0	0	398	550	812	3,856	3,856	0
From Fuel Imports	250	250	250							250	250	250	1,500	1,500	0
From Energy Imports	666	481	199	0						148	300	562	2,356	2,356	0
Annual Deficit													1,501		
2005 Capacity Balance															
KYG Peak Demand 2005 MW	2,890	2,789	2,719	1,599	1,276	1,209	1,225	1,201	1,163	2,036	2,515	2,944			
Surplus/Deficit Capacity	-96	-29	2	1095	1429	1549	1597	1652	1698	827	336	-123			

APPENDIX D: CALCULATIONS AND RESULTS OF THE NARYN CASCADE OPERATION STUDY

Toktogul Operating Regime T 65 (Summer 65%: 7,840 mcm)

	J	F	M	A	M	J	J	A	S	O	N	D			
Toktogul															
Inflow mcm	401	355	405	688	1554	2480	2280	1439	790	684	512	434	12022		
Outflow mcm	771	660	660	1260	1360	1360	1300	1300	1260	660	660	771	12022		
Reservoir BOM	18,500	18,130	17,825	17,570	16,998	17,192	18,312	19,292	19,431	19,400	19,424	19,276			
Reservoir EOM	18,130	17,825	17,570	16,998	17,192	18,312	19,292	19,431	19,500	19,424	19,276	18,939			
Avg. Reservoir Content	18,315	17,978	17,698	17,284	17,095	17,752	18,802	19,362	19,466	19,412	19,350	19,108			
Head	170	169	167	166	165	168	173	175	176	176	175	174			
Gwh/mcm	0.408	0.405	0.401	0.397	0.395	0.402	0.414	0.420	0.421	0.421	0.420	0.417			
MW	1127	1106	1089	1064	1052	1092	1157	1191	1198	1195	1191	1176			
Gwh	315	267	265	500	537	547	538	546	531	278	277	322	4923		
											Summer		7840		
Kurpsai															
Inflow mcm	771	660	660	1260	1360	1360	1300	1300	1260	660	660	771	12022		
Gwh/mcm	0.221	0.221	0.221	0.221	0.221	0.221	0.221	0.221	0.221	0.221	0.221	0.221			
MW	800	800	800	800	800	800	800	800	800	800	800	800			
Gwh	170	146	146	278	301	301	287	287	278	146	146	170	2657		
Tributary Inflow mcm	50	45	71	181	262	211	131	76	55	52	52	44	1230		
Tashumyr															
Inflow mcm	821	705	731	1441	1622	1571	1431	1376	1315	712	712	815	13252		
Gwh/mcm	0.127	0.127	0.127	0.127	0.127	0.127	0.127	0.127	0.127	0.127	0.127	0.127			
MW	450	450	450	450	450	450	450	450	450	450	450	450			
Gwh	104	90	93	183	206	200	182	175	167	90	90	104	1683		
Shamaldysai															
Inflow mcm	821	705	731	1441	1622	1571	1431	1376	1315	712	712	815	13252		
Gwh/mcm	0.062	0.062	0.062	0.062	0.062	0.062	0.062	0.062	0.062	0.062	0.062	0.062			
MW	240	240	240	240	240	240	240	240	240	240	240	240			
Gwh	51	44	45	89	101	97	89	85	82	44	44	51	822		
Uch Kurgan															
Inflow mcm	821	705	731	1441	1622	1571	1431	1376	1315	712	712	815	13252		
Gwh/mcm	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07			
MW	180	180	180	180	180	180	180	180	180	180	180	180			
Gwh	57	49	51	101	114	110	100	96	92	50	50	57	928		
														Winter	Summer
Total Hydro Gwh	698	596	600	1152	1257	1254	1196	1190	1150	608	608	703	11012	3813	7200
Total Hydro Capacity	2797	2776	2759	2734	2722	2762	2827	2861	2868	2865	2861	2846			
2005 Energy Balance															
KYG Energy Demand	1,688	1,629	1,389	759	605	574	581	570	552	1,040	1,377	1,719	12,484	8,843	3,641
Hydro Surplus	0	0	0	393	652	680	615	620	598	0	0	0	3,559	0	3,559
Energy Deficit	990	1,034	789							432	769	1,016	5,031	5,031	0
From Fuel Imports	250	250	250							250	250	250	1,500	1,500	
From Energy Imports	740	784	539							182	519	766	3,531	3,531	
Annual Deficit													1,472		
2005 Capacity Balance															
KYG Peak Demand 2005 MW	2,890	2,789	2,719	1,599		1,209	1,225	1,201	1,163	2,036					
Surplus/Deficit Capacity	-93	-13	40	1134		1553	1602	1661	1705	828					

APPENDIX E: KAMBARATA #1 CONSTRUCTION COST ESTIMATES

	Revised with data from Ertan					Harza 1993			
	Quantity	Unit	Unit Price (US$)	Amount US$	Explanation of Revision	Quantity	Unit	Unit Price (US$)	Amount US$
Preparatory Works	1	LS	35,000,000	35,000,000	Ertan Unit Lump Sum	1	LS	27,000,000	27,000,000
Diversion and Care of Water	1	LS	15,000,000	15,000,000	Ertan Unit Lump Sum*.7	1	LS		
Common Excavation	655,900	cu M	6.0	3,935,400	Ertan Unit Price	655,900	cu M	1.1	721,490
Open Rock Excavation	5,413,200	cu M	8.6	46,553,520	Ertan Unit Price	5,413,200	cu M	4.1	22,194,120
Underground Excavation	214,700	cu M	86.0	18,464,200	Ertan Unit Price	214,700	cu M	56.0	12,023,200
Shaft Excavation	23,500	cu M	60.0	1,410,000	Ertan Unit Price	23,500	cu M	77.0	1,809,500
Backfill	490,200	cu M	2.1	1,029,420	Ertan Unit Price	490,200	cu M	2.1	1,029,420
Powerhouse Concrete	163,800	cu M	87.0	14,250,600	Ertan Unit Price	163,800	cu M	100.0	16,380,000
Dam and SpillwayConcrete	3,521,900	cu M	66.0	232,445,400	Ertan Unit Price	3,521,900	cu M	110.0	387,409,000
Other Reinforced Concrete	228,800	cu M	120.0	27,456,000	Ertan Unit Price	228,800	cu M	220.0	50,336,000
Underground Concrete	94,500	cu M	130.0	12,285,000	Ertan Unit Price	94,500	cu M	241.0	22,774,500
Grouting		LS	27,300,000	27,300,000	Harza Lump Sum	1	LS	27,300,000	27,300,000
Steel Liners	12,700	ton	3,360	42,672,000	Ertan Unit Price	12,700	ton	2,062	26,187,400
Structural Steel	10,400	ton	2,106	21,902,400	Harza Unit Price	10,400	ton	2,106	21,902,400
Rockbolts					Included in Excavation	1,156	ton	3,310	3,826,360
Turbine/Generator/Transformer	1,200	MW	120,000	144,000,000	Ertan Cost/MW	1,700	MW	220,000	374,000,000
Misc.Mechanical & Electoral	1	LS	16,000,000	16,000,000	Harza LS	1	LS	16,000,000	16,000,000
Gates,Cranes and Hoists	1	LS	37,000,000	37,000,000	Harza LS	1	LS	37,000,000	37,000,000
Switchyard	1	LS	12,000,000	12,000,000	Harza LS	1	LS	12,000,000	12,000,000
Substation	1	LS	20,000,000	20,000,000	Harza LS	1	LS	20,000,000	20,000,000
500 kv Transmission Line	260	km	400,000	104,000,000	Ertan $/km	706	km	374,000	264,044,000
Base Cost				832,703,940					1,343,937,390
Contingencies	20% of Civil Works			99,940,788		25% of total			335,984,348
Engineering and Administration	7% of Total			65,285,131		10% of total			167,992,174
TOTAL				997,929,859					1,847,913,911
In 2002 constant dollars(No change in MUV 1990 to 2000)				997,929,859					
Add 20% (conditions less favorable than China)				1,197,515,830.75					

APPENDIX F: KAMBARATA #2 CONSTRUCTION COST ESTIMATES

	Revised with data from Ertan				Harza 1993				
	Quantity	Unit	Unit Price (US$)	Amount US$	Explanation of Revision	Quantity	Unit	Unit Price (US$)	Amount US$
Preparatory Works	1	LS	3,400,000	3,400,000	Harza Lump Sum	1	LS	3,400,000	3,400,000
Diversion and Care of Water	1	LS	5,000,000	5,000,000	Estimate				
Common Excavation	538,000	cu M	6.0	3,228,000	Ertan Unit Price	538,000	cu M	1.1	591,800
Open Rock Excavation	12,300	cu M	8.6	105,780	Ertan Unit Price	12,300	cu M	4.1	50,430
Underground Excavation	215,300	cu M	86.0	18,515,800	Ertan Unit Price	215,300	cu M	56.0	12,056,800
Embankment	1,296,000	cu M	3.4	4,406,400	Harza Unit Price	1,296,000	cu M	3.4	4,406,400
Backfill	507,100	cu M	2.1	1,064,910	Ertan Unit Price	507,100	cu M	1.1	557,810
Powerhouse Concrete	198,900	cu M	87.0	17,304,300	Ertan Unit Price	198,900	cu M	150.0	29,835,000
Underground Concrete	94,500	cu M	130.0	12,285,000	Ertan Unit Price	157,800	cu M	230.0	36,294,000
Grouting	158,000	LS	38	6,004,000	Harza Unit Price	158,000	sq M	38	6,004,000
Steel Liners	5,510	ton	3,360	18,513,600	Ertan Unit Price	5,510	ton	2,062	11,361,620
Structural Steel	300	ton	2,106	631,800	Harza Unit Price	300	ton	2,106	631,800
Galvanized Steel	590	ton	3,000	1,770,000	Harza Unit Price	590	ton	3,000	1,770,000
Rockbolts	803		3,310	2,657,930	Harza Unit Price	803	ton	3,310	2,657,930
Turbine/Generator	400	MW	130,000	52,000,000	Ertan $/MW				
Transformers	2	each	1,200,000	2,400,000		2	each	1,200,000	2,400,000
Generators						2	each	9,600,000	19,200,000
Misc.Mechanical	1	LS	11,600,000	11,600,000	Harza Lump Sum	1	LS	11,600,000	11,600,000
Misc. Electrical	1	LS	2,160,000	2,160,000	Harza Lump Sum	1	LS	2,160,000	2,160,000
Gates,Cranes and Hoists	1	LS	12,836,000	12,836,000	Harza Lump Sum	1	LS	12,836,000	12,836,000
Switchyard	1	LS	6,000,000	6,000,000	Harza Lump Sum	1	LS	6,000,000	6,000,000
500 kv Transmission Line	47	km	374,000	17,578,000	Harza $/km	47	km	374,000	17,578,000
Subtotal				199,461,520					181,391,590
Contingencies	30% of Civil Works			18,977,504		30% Civil Works and 20% of other items			31,807,000
Engineering and Administration	7% of Total			15,290,732		10% of total			25,536,000
TOTAL				233,729,756					258,734,590
In 2002 constant dollars(No change in MUV 1990 to 2000)				233,729,756					
Add 20% (conditions less favorable than China)				280,475,706.82					

Additional Costs:

Turbine/Generator	200	MW	130,000	26,000,000
Transformers	1	each	1,200,000	1,200,000
Misc.Mechanical	1	LS	5,000,000	5,000,000
Misc. Electrical	1	LS	1,000,000	1,000,000
Civil Works (in contingency &eng.)				10,000,000
Subtotal				43,200,000
TOTAL				323,675,706.82

APPENDIX G: SYSTEM OPERATION STUDIES

KAMBARATA #1 AND #2 WITH TOKTOGUL AND CASCADE
ALTERNATIVE A

TOKTOGUL REGIME T65 (7,840 BCM RELEASE, APRIL TO SEPTEMBER)
K#1 RULE CURVE RW TO MAXIMIZE WINTER ENERGY

	J	F	M	A	M	J	J	A	S	O	N	D	
Kambarata #1													
Inflow mcm	324	342	379	673	1353	2201	1857	1256	711	523	458	384	10,463
Rule Curve	0.45	0.25	0.10	0.08	0.25	0.65	0.95	1.00	1.00	0.90	0.80	0.65	
Outflow mcm	1,224	1,242	1,054	763	588	401	507	1,031	711	973	908	1,059	10,463
Reservoir BOM	2,925	2,025	1,125	450	360	1,125	2,925	4,275	4,500	4,500	4,050	3,600	
Reservoir EOM	2,025	1,125	450	360	1,125	2,925	4,275	4,500	4,500	4,050	3,600	2,925	
Avg. Reservoir Content	2,475	1,575	788	405	743	2,025	3,600	4,388	4,500	4,275	3,825	3,263	
Avg.Head	185	155	124	107	122	171	216	232	233	230	221	208	
Gwh/mcm	0.445	0.371	0.296	0.256	0.291	0.410	0.517	0.555	0.560	0.550	0.529	0.497	
MW	953	796	635	548	625	878	1108	1190	1200	1180	1134	1067	
Gwh	544	461	312	195	171	164	262	572	398	536	480	527	4,624
Full gate Gwh	696	581	463	400	456	641	809	869	876	861	828	779	
Plant factor %	78	79	67	49	38	26	32	66	45	62	58	68	
Kambarata #2													
Inflow	1,224	1,242	1,054	763	588	401	507	1,031	711	973	908	1,059	
Outflow	1224	1242	1054	763	588	401	507	1031	711	973	908	1059	
Gwh/mcm	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	
MW	600	600	600	600	600	600	600	600	600	600	600	600	
Gwh	147	149	127	92	71	48	61	124	85	117	109	127	1,256
Full Gate Output	438	438	438	438	438	438	438	438	438	438	438	438	
Plant Factor	34	34	29	21	16	11	14	28	19	27	25	29	
Tributary Inflow mcm	77	13	26	15	191	289	423	183	79	161	54	50	1,560
Toktogul													
Inflow mcm	1301	1255	1080	778	779	690	930	1214	790	1134	962	1109	12,022
Outflow mcm	660	660	771	1260	1360	1360	1300	1300	1260	660	660	771	12,022
Reservoir BOM	18,000	18,641	19,236	19,545	19,063	18,482	17,812	17,442	17,356	19,000	19,474	19,000	
Reservoir EOM	18,641	19,236	19,545	19,063	18,482	17,812	17,442	17,356	16,886	19,474	19,400	19,338	
Avg. Reservoir Content	18,321	18,939	19,391	19,304	18,773	18,147	17,627	17,399	17,121	19,237	19,437	19,169	
Head	170	173	175	175	173	170	167	166	165	175	176	174	
Gwh/mcm	0.409	0.415	0.421	0.420	0.414	0.407	0.401	0.398	0.395	0.419	0.421	0.418	
MW	1127	1165	1193	1188	1155	1117	1085	1071	1054	1184	1196	1180	
Gwh	270	274	324	529	563	553	521	518	498	276	278	322	4,925
Plant Factor	33	32	37	61	67	68	66	66	65	32	32	37	
											Summer		7,840
Kurpsai													
Inflow mcm	660	660	771	1260	1360	1360	1300	1300	1260	660	660	771	12,022
Gwh/mcm	0.221	0.221	0.221	0.221	0.221	0.221	0.221	0.221	0.221	0.221	0.221	0.221	
MW	800	800	800	800	800	800	800	800	800	800	800	800	
Gwh	146	146	170	278	301	301	287	287	278	146	146	170	2,657
Tributary Inflow mcm	50	45	71	181	262	211	131	76	55	52	52	44	1,230
Tashkumyr													
Inflow mcm	710	705	842	1441	1622	1571	1431	1376	1315	712	712	815	13,252
Gwh/mcm	0.127	0.127	0.127	0.127	0.127	0.127	0.127	0.127	0.127	0.127	0.127	0.127	
MW	450	450	450	450	450	450	450	450	450	450	450	450	
Gwh	90	90	107	183	206	200	182	175	167	90	90	104	1,683
Shamaldysai													
Inflow mcm	710	705	842	1441	1622	1571	1431	1376	1315	712	712	815	13,252
Gwh/mcm	0.062	0.062	0.062	0.062	0.062	0.062	0.062	0.062	0.062	0.062	0.062	0.062	
MW	240	240	240	240	240	240	240	240	240	240	240	240	
Gwh	44	44	52	89	101	97	89	85	82	44	44	51	822
Uch Kurgan													
Inflow mcm	710	705	842	1441	1622	1571	1431	1376	1315	712	712	815	13,252
Gwh/mcm	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	
MW	180	180	180	180	180	180	180	180	180	180	180	180	
Gwh	50	49	59	101	114	110	100	96	92	50	50	57	928
Cascade Hydro	599	603	713	1,180	1,283	1,260	1,179	1,161	1,117	607	608	704	11,014
Total Hydro GWh	1,291	1,213	1,151	1,467	1,525	1,473	1,502	1,857	1,600	1,259	1,197	1,358	16,893
Hydro Capacity MW	4,351	4,232	4,098	4,006	4,050	4,265	4,463	4,531	4,523	4,634	4,600	4,516	

SUMMARY ALTERNATIVE A: T65/RW

	J	F	M	A	M	J	J		S	O	N	D	TOTALS ANNUAL	TOTALS WINTER	TOTALS SUMMER
Total Hydro GWh	1,291	1,213	1,151	1,467	1,525	1,473	1,502	1,857	1,600	1,259	1,197	1,358	16,893	7,469	9,424
Hydro Capacity MW	4,351	4,232	4,098	4,006	4,050	4,265	4,463	4,531	4,523	4,634	4,600	4,516			
2010 Energy Balance															
KYG Energy Demand	1,485	1,485	1,315	1,055	768	742	742	742	755	1,146	1,302	1,485	13,024	8,218	4,806
Hydro Surplus	0	0	0	412	757	731	760	1,115	845	113	0	0	4,731	113	4,618
Thermal Deficit	194	272	164	0	0	0	0	0	0	0	105	127	862	862	0
Supplied by Fuel Imports	194	250	164							0	105	127	840	840	0
Supplied by Energy Imp	0	22	0								0	0	22	22	0
Annual Energy Surplus													3,869		0
2010 Capacity Balance															
KYG Peak Demand	3,129	3,129	2,772	2,628	1,914	1,849	1,849	1,849	1,881	2,415	2,745	3,129			
Surplus Capacity	1,221	1,102	1,326	1,379	2,136	2,416	2,614	2,682	2,642	2,218	1,855	1,387			
2015 Energy Balance															
KYG Energy Demand	1,584	1,584	1,403	1,125	820	792	792	792	806	1,223	1,389	1,584	13,893	8,766	5,127
Hydro Surplus	0	0	0	342	706	681	710	1,065	794	36	0	0	4,334	36	4,298
Thermal Deficit	293	371	252	0	0	0	0	0	0	0	192	226	1,334	1,334	0
Supplied by Fuel Imports	250	250	250							0	192	226	1,168	1,168	0
Supplied by Energy Imp	43	121	2							0	0	0	166	166	0
Annual Energy Surplus													3,000	3,000	0
2015 Capacity Balance															
KYG Peak Demand MW	3,338	3,338	2,957	2,372	1,727	1,669	1,669	1,669	1,698	2,577	2,928	3,338			
Surplus Capacity	1,013	894	1,141	1,635	2,323	2,596	2,794	2,862	2,825	2,057	1,672	1,178			

KAMBARATA #1 AND #2 WITH TOKTOGUL AND CASCADE
ALTERNATIVE B

TOKTOGUL REGIME T65 (7,840 BCM RELEASE, APRIL TO SEPTEMBER)
KI RULE CURVE RA TO MAXIMIZE ANNUAL ENERGY

		F	M	A	M	J	J	A	S	O	N	D	Totals
Kambarata #1													
Inflow mcm	324	342	379	673	1,353	2,201	1,857	1,256	711	523	458	384	10463
Rule Curve	0.94	0.91	0.89	0.90	0.90	0.90	1.00	1.00	1.00	1.00	0.99	0.97	
Outflow mcm	459	477	469	628	1,353	2,201	1,407	1,256	711	523	503	474	10463
Reservoir BOM	4,365	4,230	4,095	4,005	4,050	4,050	4,050	4,500	4,500	4,500	4,500	4,455	
Reservoir EOM	4,230	4,095	4,005	4,050	4,050	4,050	4,500	4,500	4,500	4,500	4,455	4,365	
Avg. Reservoir Content	4,298	4,163	4,050	4,028	4,050	4,050	4,275	4,500	4,500	4,500	4,478	4,410	
Avg.Head	230	227	225	225	225	225	230	233	233	233	233	232	
Gwh/mcm	0.551	0.545	0.540	0.539	0.540	0.540	0.550	0.560	0.560	0.560	0.559	0.556	
MW	1,182	1,169	1,158	1,155	1,158	1,158	1,180	1,200	1,200	1,200	1,198	1,192	
Gwh	253	260	253	338	731	1,189	774	703	398	293	281	263	5,737
Full gate Gwh	863	853	845	843	845	845	861	876	876	876	874	870	
Plant factor %	29	30	30	40	86	141	90	80	45	33	32	30	
Kambarata #2													
Inflow	459	477	469	628	1,353	2,201	1,407	1,256	711	523	503	474	10,463
Outflow	459	477	469	628	1,353	2,201	1,407	1,256	711	523	503	474	
Gwh/mcm	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	
MW	600	600	600	600	600	600	600	600	600	600	600	600	
Gwh	55	57	56	75	162	264	169	151	85	63	60	57	1,256
Full Gate Output	438	438	438	438	438	438	438	438	438	438	438	438	
Plant Factor	13	13	13	17	37	60	39	34	19	14	14	13	
Tributary Inflow mcm	77	13	26	15	191	289	423	183	79	161	54	50	1,560
Toktogul													
Inflow mcm	536	490	495	643	1,544	2,490	1,830	1,439	790	684	557	524	12,022
Outflow mcm	660	660	771	1,260	1,360	1,360	1,300	1,300	1,260	771	660	660	12,022
Reservoir BOM	18,000	17,876	17,706	17,430	16,813	16,997	18,127	18,657	18,796	19,000	18,913	19,000	
Reservoir EOM	17,876	17,706	17,430	16,813	16,997	18,127	18,657	18,796	18,326	18,913	19,400	18,864	
Avg. Reservoir Content	17,938	17,791	17,568	17,122	16,905	17,562	18,392	18,727	18,561	18,957	19,157	18,932	
Head	169	168	167	165	164	167	171	172	172	173	174	173	
Gwh/mcm	0.404	0.403	0.400	0.395	0.393	0.400	0.409	0.413	0.411	0.416	0.418	0.415	
MW	1,104	1,095	1,081	1,054	1,040	1,081	1,132	1,152	1,142	1,167	1,179	1,165	
Gwh	267	266	308	498	534	544	532	537	518	321	276	274	4,874
Plant Factor	33	33	39	65	70	69	64	64	62	38	32	32	
											Summer		7,840
Kurpsai													
Inflow mcm	660	660	771	1,260	1,360	1,360	1,300	1,300	1,260	771	660	660	12,022
Gwh/mcm	0.221	0.221	0.221	0.221	0.221	0.221	0.221	0.221	0.221	0.221	0.221	0.221	
MW	800	800	800	800	800	800	800	800	800	800	800	800	
Gwh	146	146	170	278	301	301	287	287	278	170	146	146	2,657
Tributary Inflow mcm	50	45	71	181	262	211	131	76	55	52	52	44	1,230
Tashkumyr													
Inflow mcm	710	705	842	1,441	1,622	1,571	1,431	1,376	1,315	823	712	704	13,252
Gwh/mcm	0.127	0.127	0.127	0.127	0.127	0.127	0.127	0.127	0.127	0.127	0.127	0.127	
MW	450	450	450	450	450	450	450	450	450	450	450	450	
Gwh	90	90	107	183	206	200	182	175	167	105	90	89	1,683
Shamaldysai													
Inflow mcm	710	705	842	1,441	1,622	1,571	1,431	1,376	1,315	823	712	704	13,252
Gwh/mcm	0.062	0.062	0.062	0.062	0.062	0.062	0.062	0.062	0.062	0.062	0.062	0.062	
MW	240	240	240	240	240	240	240	240	240	240	240	240	
Gwh	44	44	52	89	101	97	89	85	82	51	44	44	822
Uch Kurgan													
Inflow mcm	710	705	842	1,441	1,622	1,571	1,431	1,376	1,315	823	712	704	13,252
Gwh/mcm	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	
MW	180	180	180	180	180	180	180	180	180	180	180	180	
Gwh	50	49	59	101	114	110	100	96	92	58	50	49	928
Cascade Hydro	597	594	697	1,149	1,254	1,251	1,190	1,181	1,137	704	606	602	10,963
Total Hydro Gwh	905	911	1,007	1,563	2,148	2,704	2,133	2,034	1,621	1,060	948	923	17,956
Hydro Capacity	4,556	4,534	4,509	4,479	4,468	4,508	4,582	4,622	4,612	4,636	4,647	4,627	

SUMMARY ALTERNATIVE B: T65/RA

	J	F	M	A	M	J	J	A	S	O	N	D		WINTER	SUMMER
Total Hydro Gwh	905	911	1,007	1,563	2,148	2,704	2,133	2,034	1,621	1,060	948	923	17,956	5,753	12,203
Peaking Capacity	4,556	4,534	4,509	4,479	4,468	4,508	4,582	4,622	4,612	4,636	4,647	4,627			
2010 Energy Balance															
KYG Energy Demand	1,485	1,485	1,315	1,055	768	742	742	742	755	1,146	1,302	1,485	13,024	8,218	4,806
Hydro Surplus	0	0	0	508	1,379	1,962	1,391	1,292	865	0	0	0	7,397	0	7,397
Thermal Deficit	580	573	309	0	0	0	0	0	0	86	355	562	2,465	2,465	0
Supplied by Fuel Import	250	250	250							59	250	250	1,309	1,309	0
Supplied by Energy Imp	330	323	59							27	105	312	1,156	1,156	0
Annual Surplus													4,932		
2010 Capacity Balance															
KYG Peak Demand MW	3,129	3,129	2,772	2,628	1,914	1,849	1,849	1,849	1,881	2,415	2,745	3,129			
Surplus Capacity	1,427	1,405	1,737	1,852	2,554	2,659	2,733	2,773	2,731	2,221	1,902	1,498			
2015 Energy Balance															
KYG Energy Demand	1,584	1,584	1,403	1,125	820	792	792	792	806	1,223	1,389	1,584	13,893	8,766	5,127
Hydro Surplus	0	0	0	438	1,328	1,912	1,341	1,242	815	0	0	0	7,077	0	7,077
Thermal Deficit	679	672	397	0	0	0	0	0	0	163	442	661	3,014	3,014	0
Supplied by Fuel Impor	250	250	250							163	250	250	1,500	1,500	0
Supplied by Energy Im	429	422	147							0	192	411	1,514	1,514	0
Annual Surplus													4,063		
2015 Capacity Balance															
KYG Peak Demand MW	3,338	3,338	2,957	2,372	1,727	1,669	1,669	1,669	1,698	2,577	2,928	3,338			
Surplus Capacity	1,218	1,196	1,552	2,107	2,741	2,840	2,913	2,953	2,914	2,060	1,719	1,289			

PPENDIX G: SYSTEM OPERATION STUDIES

KAMBARATA #1 AND #2 WITH TOKTOGUL AND CASCADE
ALTERNATIVE C

TOKTOGUL REGIME T55 (6,500 BCM RELEASE, APRIL TO SEPTEMBER)
K#1 RULE CURVE RW TO MAXIMIZE WINTER ENERGY

	J	F	M	A	M	J	J	A	S	O	N	D	
Kambarata #1													
Inflow mcm	324	342	379	673	1353	2201	1857	1256	711	523	458	384	10,463
Rule Curve	0.45	0.25	0.10	0.08	0.25	0.65	0.95	1.00	1.00	0.90	0.80	0.65	
Outflow mcm	1,224	1,242	1,054	763	588	401	507	1,031	711	973	908	1,059	10,463
Reservoir BOM	2,925	2,025	1,125	450	360	1,125	2,925	4,275	4,500	4,500	4,050	3,600	
Reservoir EOM	2,025	1,125	450	360	1,125	2,925	4,275	4,500	4,500	4,050	3,600	2,925	
Avg. Reservoir Content	2,475	1,575	788	405	743	2,025	3,600	4,388	4,500	4,275	3,825	3,263	
Avg.Head	185	155	124	107	122	171	216	232	233	230	221	208	
Gwh/mcm	0.445	0.371	0.296	0.256	0.291	0.410	0.517	0.555	0.560	0.550	0.529	0.497	
MW	953	796	635	548	625	878	1108	1190	1200	1180	1134	1067	
Gwh	544	461	312	195	171	164	262	572	398	536	480	527	4,624
Full gate Gwh	696	581	463	400	456	641	809	869	876	861	828	779	
Plant factor %	78	79	67	49	38	26	32	66	45	62	58	68	
Kambarata #2													
Inflow	1,224	1,242	1,054	763	588	401	507	1,031	711	973	908	1,059	
Outflow	1224	1242	1054	763	588	401	507	1031	711	973	908	1059	
Gwh/mcm	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	
MW	600	600	600	600	600	600	600	600	600	600	600	600	
Gwh	147	149	127	92	71	48	61	124	85	117	109	127	1,256
Full Gate Output	438	438	438	438	438	438	438	438	438	438	438	438	
Plant Factor	34	34	29	21	16	11	14	28	19	27	25	29	
Tributary Inflow mcm	77	13	26	15	191	289	423	183	79	161	54	50	1,560
Toktogul													
Inflow mcm	1301	1255	1080	778	779	690	930	1214	790	1134	962	1109	12,022
Outflow mcm	855	1005	1055	900	1000	1300	1400	1300	600	698	905	1004	12,022
Reservoir BOM	18,000	18,446	18,696	18,721	18,599	18,378	17,768	17,298	17,212	19,000	19,436	19,000	
Reservoir EOM	18,446	18,696	18,721	18,599	18,378	17,768	17,298	17,212	17,402	19,436	19,400	19,105	
Avg. Reservoir Content	18,223	18,571	18,709	18,660	18,489	18,073	17,533	17,255	17,307	19,218	19,418	19,053	
Head	170	172	172	172	171	169	167	165	166	175	176	174	
Gwh/mcm	0.407	0.411	0.413	0.412	0.410	0.406	0.400	0.396	0.397	0.419	0.421	0.417	
MW	1121	1143	1151	1148	1138	1112	1079	1062	1065	1183	1195	1172	
Gwh	348	413	436	371	410	527	559	515	238	292	381	418	4,911
Plant Factor	43	50	52	44	49	65	71	66	31	34	44	49	
											Summer		6,500
Kurpsai													
Inflow mcm	855	1005	1055	900	1000	1300	1400	1300	600	698	905	1004	12,022
Gwh/mcm	0.221	0.221	0.221	0.221	0.221	0.221	0.221	0.221	0.221	0.221	0.221	0.221	
MW	800	800	800	800	800	800	800	800	800	800	800	800	
Gwh	189	222	233	199	221	287	309	287	133	154	200	222	2,657
Tributary Inflow mcm	50	45	71	181	262	211	131	76	55	52	52	44	1,230
Tashkumyr													
Inflow mcm	905	1050	1126	1081	1262	1511	1531	1376	655	750	957	1048	13,252
Gwh/mcm	0.127	0.127	0.127	0.127	0.127	0.127	0.127	0.127	0.127	0.127	0.127	0.127	
MW	450	450	450	450	450	450	450	450	450	450	450	450	
Gwh	115	133	143	137	160	192	194	175	83	95	122	133	1,683
Shamaldysai													
Inflow mcm	905	1050	1126	1081	1262	1511	1531	1376	655	750	957	1048	13,252
Gwh/mcm	0.062	0.062	0.062	0.062	0.062	0.062	0.062	0.062	0.062	0.062	0.062	0.062	
MW	240	240	240	240	240	240	240	240	240	240	240	240	
Gwh	56	65	70	67	78	94	95	85	41	47	59	65	822
Uch Kurgan													
Inflow mcm	905	1050	1126	1081	1262	1511	1531	1376	655	750	957	1048	13,252
Gwh/mcm	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	
MW	180	180	180	180	180	180	180	180	180	180	180	180	
Gwh	63	74	79	76	88	106	107	96	46	53	67	73	928
Cascade Hydro	772	907	960	850	958	1,206	1,265	1,159	540	641	829	912	11,000
Total Hydro GWh	1,463	1,518	1,399	1,137	1,200	1,419	1,588	1,855	1,024	1,293	1,418	1,566	16,879

Hydro Capacity MW	4,345	4,209	4,056	3,967	4,033	4,260	4,457	4,522	4,535	4,632	4,599	4,509

SUMMARY ALTERNATIVE C: T55/RW

		F	M	A	M	J	J	A	S	O	N	D	TOTALS ANNUAL	WINTER	SUMMER
Total Hydro GWh	1,463	1,518	1,399	1,137	1,200	1,419	1,588	1,855	1,024	1,293	1,418	1,566	16,879	8,656	8,223
Hydro Capacity MW	4,345	4,209	4,056	3,967	4,033	4,260	4,457	4,522	4,535	4,632	4,599	4,509			
2010 Energy Balance															
KYG Energy Demand	1,485	1,485	1,315	1,055	768	742	742	742	755	1,146	1,302	1,485	13,024	8,218	4,806
Hydro Surplus	0	33	84	82	432	676	846	,113	269	147	116	81	3,679		
Thermal Deficit	22	0	0	0	0	0	0	0	0	0	0	0	22	22	0
Supplied by Fuel Import:	22	0	0	0							0	0	22	22	0
Supplied by Energy Imp	0	0	0	0							0	0	0	0	0
Annual Surplus													3,657		
2010 Capacity Balance															
KYG Peak Demand	3,129	3,129	2,772	2,628	1,914	1,849	1,849	1,849	1,881	2,415	2,745	3,129			
Surplus Capacity	1,215	1,080	1,284	1,339	2,119	2,411	2,608	2,673	2,653	2,217	1,854	1,380			
2015 Energy Balance															
KYG Energy Demand	1,584	1,584	1,403	1,125	820	792	792	792	806	1,223	1,389	1,584	13,893	8,766	5,127
Hydro Surplus	0	0	0	11	381	627	797	1,063	218	70	29	0	3,196		
Thermal Deficit	121	66	4	0	0	0	0	0	0	0	0	18	209	209	0
Supplied by Fuel Import	121	66	4	0						0	0	18	209	209	0
Supplied by Energy Imp	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Annual Surplus													2,986		
2015 Capacity Balance															
KYG Peak Demand MW	3,338	3,338	2,957	2,372	1,727	1,669	1,669	1,669	1,698	2,577	2,928	3,338			
Surplus Capacity	1,007	871	1,099	1,595	2,305	2,592	2,788	2,853	2,837	2,056	1,671	1,171			

PPENDIX G: SYSTEM OPERATION STUDIES

KAMBARATA #1 AND #2 WITH TOKTOGUL AND CASCADE
ALTERNATIVE D

TOKTOGUL REGIME T55 (6,500 BCM RELEASE,APRIL TO SEPTEMBER)
K#1 RULE CURVE RA TO MAXIMIZE ANNUAL ENERGY

	J	F	M	A	M	J	J	A	S	O	N	D	
Kambarata #1													
Inflow mcm	324	342	379	673	1353	2201	1857	1256	711	523	458	384	10,463
Rule Curve	0.94	0.91	0.89	0.90	0.90	0.90	1.00	1.00	1.00	1.00	0.99	0.97	
Outflow mcm	459	477	469	628	1,353	2,201	1,407	1,256	711	523	503	474	10,463
Reservoir BOM	4,365	4,230	4,095	4,005	4,050	4,050	4,050	4,500	4,500	4,500	4,500	4,455	
Reservoir EOM	4,230	4,095	4,005	4,050	4,050	4,050	4,500	4,500	4,500	4,500	4,455	4,365	
Avg. Reservoir Content	4,298	4,163	4,050	4,028	4,050	4,050	4,275	4,500	4,500	4,500	4,478	4,410	
Avg.Head	230	227	225	225	225	225	230	233	233	233	233	232	
Gwh/mcm	0.551	0.545	0.540	0.539	0.540	0.540	0.550	0.560	0.560	0.560	0.559	0.556	
MW	1182	1169	1158	1155	1158	1158	1180	1200	1200	1200	1198	1192	
Gwh	253	260	253	338	731	1189	774	703	398	293	281	263	5,737
Full gate Gwh	863	853	845	843	845	845	861	876	876	876	874	870	
Plant factor %	29	30	30	40	86	141	90	80	45	33	32	30	
Kambarata #2													
Inflow	459	477	469	628	1,353	2,201	1,407	1,256	711	523	503	474	
Outflow	459	477	469	628	1353	2201	1407	1256	711	523	503	474	
Gwh/mcm	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	
MW	600	600	600	600	600	600	600	600	600	600	600	600	
Gwh	55	57	56	75	162	264	169	151	85	63	60	57	1,256
Full Gate Output	438	438	438	438	438	438	438	438	438	438	438	438	
Plant Factor	13	13	13	17	37	60	39	34	19	14	14	13	
Tributary Inflow mcm	77	13	26	15	191	289	423	183	79	161	54	50	1,560
Toktogul													
Inflow mcm	536	490	495	643	1544	2490	1830	1439	790	684	557	524	12,022
Outflow mcm	905	905	1016	706	1250	1300	1300	1250	694	798	905	993	12,022
Reservoir BOM	18,000	17,631	17,216	16,695	16,632	16,926	18,116	18,646	18,835	19,000	18,886	19,000	
Reservoir EOM	17,631	17,216	16,695	16,632	16,926	18,116	18,646	18,835	18,931	18,886	19,400	18,531	
Avg. Reservoir Content	17,816	17,424	16,956	16,664	16,779	17,521	18,381	18,741	18,883	18,943	19,143	18,766	
Head	168	166	164	163	163	167	171	172	173	173	174	173	
Gwh/mcm	0.403	0.398	0.393	0.390	0.391	0.399	0.409	0.413	0.415	0.416	0.418	0.414	
MW	1096	1072	1043	1025	1033	1078	1131	1153	1162	1166	1178	1155	
Gwh	365	361	399	275	489	519	532	517	288	332	378	411	4,865
Plant Factor	46	46	52	37	65	66	64	61	34	39	44	49	
											Summer		6,500
Kurpsai													
Inflow mcm	905	905	1016	706	1250	1300	1300	1250	694	798	905	993	12,022
Gwh/mcm	0.221	0.221	0.221	0.221	0.221	0.221	0.221	0.221	0.221	0.221	0.221	0.221	
MW	800	800	800	800	800	800	800	800	800	800	800	800	
Gwh	200	200	225	156	276	287	287	276	153	176	200	219	2,657
Tributary Inflow mcm	50	45	71	181	262	211	131	76	55	52	52	44	1,230
Tashkumyr													
Inflow mcm	955	950	1087	887	1512	1511	1431	1326	749	850	957	1037	13,252
Gwh/mcm	0.127	0.127	0.127	0.127	0.127	0.127	0.127	0.127	0.127	0.127	0.127	0.127	
MW	450	450	450	450	450	450	450	450	450	450	450	450	
Gwh	121	121	138	113	192	192	182	168	95	108	122	132	1,683
Shamaldysai													
Inflow mcm	955	950	1087	887	1512	1511	1431	1326	749	850	957	1037	13,252
Gwh/mcm	0.062	0.062	0.062	0.062	0.062	0.062	0.062	0.062	0.062	0.062	0.062	0.062	
MW	240	240	240	240	240	240	240	240	240	240	240	240	
Gwh	59	59	67	55	94	94	89	82	46	53	59	64	822
Uch Kurgan													
Inflow mcm	955	950	1087	887	1512	1511	1431	1326	749	850	957	1037	13,252
Gwh/mcm	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	
MW	180	180	180	180	180	180	180	180	180	180	180	180	
Gwh	67	67	76	62	106	106	100	93	52	60	67	73	928
Cascade	812	807	905	661	1,157	1,198	1,190	1,136	635	728	826	899	10,954
Total Hydro GWh	1,120	1,124	1,215	1,075	2,050	2,651	2,133	1,990	1,119	1,084	,167	1,219	17,946

Hydro Capacity MW	4,548	4,511	4,471	4,451	4,460	4,506	4,581	4,623	4,632	4,636	4,646	4,617

SUMMARY ALTERNATIVE D: T55/RA

	J	F	M	A	M	J	J	A	S	O	N	D	TOTALS ANNUAL	TOTALS WINTER	TOTALS SUMMER
Total Hydro GWh	1,120	1,124	1,215	1,075	2,050	2,651	2,133	1,990	1,119	1,084	1,167	1,219	17,946	6,929	11,017
Hydro Capacity MW	4,548	4,511	4,471	4,451	4,460	4,506	4,581	4,623	4,632	4,636	4,646	4,617			
2010 Energy Balance															
KYG Energy Demand	1,485	1,485	1,315	1,055	768	742	742	742	755	1,146	1,302	1,485	13,024	8,218	4,806
Hydro Surplus	0	0	0	20	1,281	1,909	1,391	1,247	363	0	0	0	6,191		
Thermal Deficit	365	361	100	0	0	0	0	0	0	62	135	266	1,289	1,289	0
Supplied by Fuel Imports	250	250	100							62	135	250	1,048	1,048	0
Supplied by Energy Imp	115	111	0	0	0	0	0	0	0	0	0	16	127	127	0
Annual Surplus													4,903		
2010 Capacity Balance															
KYG Peak Demand	3,129	3,129	2,772	2,628	1,914	1,849	1,849	1,849	1,881	2,415	2,745	3,129			
Surplus Capacity	1,419	1,382	1,699	1,823	2,546	2,657	2,732	2,774	2,750	2,220	1,901	1,488			
2015 Energy Balance															
KYG Energy Demand	1,584	1,584	1,403	1,125	820	792	792	792	806	1,223	1,389	1,584	13,893	8,766	5,127
Hydro Surplus	0	0	0	0	1,230	1,859	1,341	1,198	313	0	0	0	5,941		
Thermal Deficit	464	460	188	51	0	0	0	0	0	139	222	365	1,888	1,837	51
Supplied by Fuel Imports	250	250	188	170						139	222	250	1,469	1,299	170
Supplied by Energy Imp	214	210	0	0	0	0	0	0	0	0	0	115	538	538	0
Annual Surplus													4,053		
2015 Capacity Balance															
KYG Peak Demand MW	3,338	3,338	2,957	2,372	1,727	1,669	1,669	1,669	1,698	2,577	2,928	3,338			
Surplus Capacity	1,210	1,173	1,514	2,079	2,733	2,837	2,912	2,954	2,934	2,059	1,718	1,279			

KAMBARATA # 2 WITHOUT KAMBARATA # 1

	J	F	M	A	M	J	J	A	S	O	N	D	Annual
Kambarata # 2													
Inflow	324	342	379	673	1353	2201	1857	1256	711	523	458	384	10,463
Outflow	324	342	379	673	1353	2201	1857	1256	711	523	458	384	
GWh/mcm	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	
MW	350	350	350	350	350	350	350	350	350	350	350	350	
GWh	39	41	46	81	162	264	223	151	85	63	55	46	1,256
Full Gate Output	256	256	256	256	256	256	256	256	256	256	256	256	
Plant Factor	15	16	18	32	64	103	87	59	33	25	22	18	