PN-ABR-098

ENERGY EFFICIENCY AUDIT REPORT

KYRGYZSTAN

BISHKEK HEATING SYSTEMS ENTERPRISE
Bishkek, Kyrgyzstan

International Resources Group, Ltd.
Washington, D.C.

June 1993

PN-ABR-098

ENERGY EFFICIENCY AUDIT REPORT

BISHKEK HEATING SYSTEMS ENTERPRISE
Bishkek, Kyrgyzstan

INTERNATIONAL RESOURCES GROUP, LTD.
Washington, DC

U.S. Energy Efficiency & Market Reform Project
New Independent States Task Force
U.S. Agency for International Development
Washington, DC 20523

June 1993

TABLE OF CONTENTS

TABLES AND FIGURES

ACRONYMS AND ABBREVIATIONS

A.I.D.	Agency for International Development
atm	atmospheres
b/d	barrels per day
Btu	British thermal unit
° C	degrees Celsius
Gcal	gigacalories
GJ	gigajoules
IRG	International Resources Group
m^3	cubic meters
MT	metric ton
MW	megawatt
NIS	Newly Independent States
NMP	Net Material Product
rb	rubles; unit of currency in NIS countries. As of March 1993, 420 rubles = US $1.

ACKNOWLEDGEMENTS

The International Resources Group (IRG) District Heating Audit Team for Kyrgyzstan would like to express sincere thanks to the management and technical staff of the Bishkek Heating Systems Enterprise (BHSE) and Bishkek Thermal Plant. Extensive preparation for and commitment to the audit work by the plant staff facilitated a productive exchange of ideas and experiences in energy management. BHSE provided valuable assistance to the project by supplying engineers to assist with the energy audits throughout the Bishkek District Heating System.

IRG would also like to thank the U.S. Agency for International Development, Newly Independent States (NIS) Task Force, Office of Energy and Infrastructure, for coordinating the activities under the Energy Efficiency and Market Reform Project. It is the hope of the IRG Energy Audit Team that the initiatives implemented under this project will contribute to improvements in energy efficiency and economic development throughout Kyrgyzstan.

EXECUTIVE SUMMARY

As part of the U.S. Agency for International Development (A.I.D.)-funded Energy Efficiency and Market Reform project, the International Resources Group (IRG) Energy Audit Team visited Kyrgyzstan in April 1992. During this time, Team members spent approximately one week conducting an energy efficiency audit of various facilities within the Bishkek Heating Systems Enterprise (BHSE) and Bishkek Thermal Energy Station #1 (TES-1) in Bishkek, Kyrgyzstan. The overall purpose of this audit was to assist BHSE and TES in identifying and implementing low- and no-cost opportunities for energy savings. Team members also trained key plant personnel in energy management techniques practiced in the United States.

To accomplish these objectives, the IRG Energy Audit Team collected data at each of the facilities selected for the audit to make informed decisions regarding energy saving opportunities. Data were compiled using plant instrumentation, audit measurements (with A.I.D.-funded infrared thermometers), plant records, and personal interviews. Following the audit, Team members returned to the U.S. to develop the specifications for, and procure, energy efficiency equipment to be used within the BHSE system to implement the initiatives identified.

Unlike other technical assistance projects, the Energy Efficiency and Market Reform Project is an action-oriented project, designed to demonstrate the potential for energy savings in the Newly Independent States through the implementation of appropriate energy efficiency projects. This audit report is designed to provide the reader with a background against which to view the activities initiated under this project.

Background

Bishkek, the capital city of Kyrgyzstan, has a highly developed district heating system -- unlike any found in the U.S. -- and is unique in both its supply and end-use configurations. The heart of this system is a large cogeneration plant which feeds process steam and hot water to users. The supply configuration utilizes hot make-up water from the heated cooling water generated by the steam turbine condensers at the plant. For end-users of system heat, the circulated water serves both space heating and domestic consumption functions.

The cogeneration plant began operating in 1961 as a small unit originally designed to meet the specific needs of a wool fabric factory. As local industrial and residential sectors grew, the plant expanded its capacity to its present size of 24 boilers and 11 steam turbines which produce 574 megawatts (MW) of electricity and supply 1,600 gigacalories (Gcal) per hour of heat at its maximum output.

As a whole, the system is relatively inefficient. Due to both institutional and technical factors such as government ownership of the system, energy subsidies, and centralized planning, the importance and significance of individual metering has long been ignored. Similarly, the billing system used by BHSE, which is based on estimated average use within the entire district, has further eliminated incentives for end-users to implement meaningful energy conservation measures.

Most equipment within the audited facilities is relatively outdated. There are few measuring devices or instruments for monitoring either supply or end-use (demand) energy. On the demand side, little individual metering is installed and in working order, and even where monitoring instruments are available, few have been utilized on a regular basis. On the supply side, monitoring and control equipment for automatic combustion are absent from the thermal power plant, and pollution monitoring and control equipment are also nonexistent.

Audit Findings, Recommendations, and General Outlook

In April 1992, the IRG Team initiated the first segment of the Energy Efficiency and Market Reform Project by assisting the Power Generating Company of Bishkek in improving the operational efficiency of their plants. This segment of the project involved developing specifications for, purchasing, and assisting in the installation of gas analyzers, heat meters, flow meters and other conservation and energy efficiency equipment to demonstrate the potential savings from such measures. To further improve energy efficiency among end-users, the installation of thermostatic valves, and controls and metering devices for residential apartment buildings is also being considered.

The IRG Energy Audit Team examined BHSE's cogeneration system and found tremendous potential for energy savings in all segments of system operation; for example, the power plant contains boilers whose only current function is to heat water. There are also opportunities to satisfy the growth in demand for power through the cogeneration of electricity. Further, since most hot water boilers within the system are fired by natural gas, they would be better suited for gas turbines with combined cycle capabilities. Although the current, artificially low electricity prices and the uncertainty of future natural gas prices and supplies appear to make investments in combined-cycle gas turbines unfeasible in the short-term, the long-term outlook for this option is very attractive.

Energy conservation, which will be encouraged through the removal of energy subsidies and the institution of rational, individual billing, has the potential to achieve an energy savings of 30% among all end-users. On the production side, improvements in efficiency resulting from the installation of modern instrumentation and controls could achieve savings of almost 20%, offering a total reduction of approximately 50% in overall energy use to Bishkek district heating systems.

In addition, new privatization laws were passed by the Kyrgyzstan government in 1992 to attract foreign companies and to facilitate their investment in the country. Under this legislation, it is now possible for foreign investors to repatriate profits in hard currency.

1. BACKGROUND

In the aftermath of the collapse of the Soviet Union, its former republics are faced with a host of economic and political crises, the most serious of which is energy. The energy sector has historically been plagued by inefficiencies resulting from subsidized pricing, lack of instrumentation and control for energy inputs, and the overall aging of the sector's infrastructure. However, during the past few years, the perennially inefficient economic system of the former Soviet Union has deteriorated further, dramatically decreasing production throughout the region. This situation adversely affected the energy sector by adding production and distribution bottlenecks to the already difficult task of procuring raw material inputs (particularly coal and natural gas) for the generation of electricity and heat.

After the termination of the Soviet Union in December 1991, long-standing inter-republic supply arrangements for energy inputs were disrupted due to political considerations. At that time, it became necessary for most republics to pay for energy supplies with scarce hard currency or through barter, aggravating the cash flow situation even further. As a result, a number of energy enterprises failed during the 1991/1992 heating season, causing tens of thousands of people to go without heat or electricity for significant periods of time.

1.1 Project Origin and Rationale

The Washington Coordinating Conference of January 1992 – which included representatives from more than 50 nations and international donor agencies – recognized the critical natura of these energy issues. To this end, its Energy Working Group developed an action plan to address those problems confronting the Newly Independent States (NIS). As part of this plan, the United States Agency for International Development (A.I.D.) agreed to fund a technical-assistance initiative to assist NIS nations in improving the performance and efficiency of selected district heating systems.

One initiative, known as the Energy Efficiency and Market Reform Project, was designed to combine in-plant, on-the-job training with the identification and implementation of low- and no-cost programs to maximize energy efficiency. The specific goals of Component #1 of this project, Heating System Energy Efficiency Improvement, are to:

1) foster better management of energy use in district heating plants by identifying and implementing inexpensive energy efficiency improvements;

2) transfer Western technologies in the conduct of energy audits and in plant management to heating system staff, including instruction in the formulation of financial and technical analyses;

3) provide support, in the form of energy efficiency equipment, to implement these identified options and to improve overall energy monitoring and management; and

4) identify additional opportunities for energy conservation and efficiency.

In each NIS nation, one or two district heating systems were selected as target enterprises for these energy efficiency audits. These systems were selected on the basis of their potential for significant energy savings, the applicability of audit results to similar plants in other countries in the NIS region, and the importance of the system's efficiency and effectiveness in the overall context of the country's economic development.

International Resources Group, Ltd. (IRG) of Washington, DC, was chosen to implement the Energy Efficiency and Market Reform Project in Kyrgyzstan. IRG Energy Audit Team members first visited the country in March 1992 to discuss energy-related needs with development officials and to develop the workplan for this project, the initial energy activity under the new U.S. Economic Assistance Program for the NIS.

As part of the project, the IRG Energy Audit Team presented a workshop for management staff of BHSE and TES to discuss key, energy-related problems, as well as possible solutions. In addition, Team members presented a brief seminar on the use of economic techniques for evaluating investment options in energy efficiency programs and equipment, as well as providing them with the tools necessary to complete the strategic planning process at the plant level. Finally, representatives of U.S.-based private-sector energy companies discussed equipment options and financing mechanisms.

Before the Team returned to the NIS in autumn 1992, IRG had procured, with A.I.D. funding, the equipment necessary to improve overall energy efficiency and to help prevent failures within the system during the heating season. BHSE and TES-1 technicians assisted in installing the equipment in the audited facilities.

1.2 Participating Entities and Roles

As mentioned above, the primary organizations involved in the implementation of the Energy Efficiency and Market Reform Project for Kyrgyzstan include A.I.D., BHSE, Bishkek Thermal Plant (TES-1) and the IRG Energy Audit Team. The State Energy Holding Company (SEHC) is overseeing the implementation of the project on behalf of the Government of Kyrgyzstan.

Mr. Jamalbek Tulyeberdievich Tuleberdiev, President of the SEHC, serves as overall advisor for the project, with Mr. Alexei Chunkchenovitch Lee, Director of BHSE, leading the project team as General Director for Kyrgyzstan. In addition, Mr. Vasiliev Lev Alexeivich, Director of TES-1, and Mr. Batakanov Mirbek Topchievich, Chief Engineer of BHSE, are primary contacts for IRG Energy Audit Team members.

Private-sector American firms specializing in energy efficiency equipment and project development participate in the project on a no-cost basis, providing additional information on equipment and financing options.

1.2.1 Audit Process

Based on guidelines established by A.I.D., and in consultation with the managerial staff of BHSE and TES-1, the IRG Energy Audit Team conducted an energy efficiency audit of the Bishkek District Heating System and Bishkek Thermal Plant. This audit resulted in the identification and implementation of several energy efficiency opportunities, examined areas where future training of BHSE and TES-1 staff was needed, and classified and prioritized purchases of energy efficiency equipment.

1.2.2 Equipment Procurement and Installation

During mid- and late-1992, IRG purchased all instrumentation and equipment as approved by A.I.D., arranged for its transfer to Bishkek, and coordinated its delivery to BHSE and/or TES-1. The Ministry of Foreign Affairs of the Government of Kyrgyzstan, in cooperation with SEHC, ensured the equipment passed through customs duty free and was delivered to the appropriate enterprise. During late-1992, the IRG Energy Audit Team returned to Kyrgyzstan and assisted engineers and technical specialists from BHSE and TES-1 in the installation of this equipment and instrumentation.

1.2.3 Seminar

IRG staff, BHSE and TES-1 personnel, and representatives from SEHC will organize a seminar in Bishkek in mid 1993 to discuss and disseminate the results of the joint Kyrgyzstan-American project. BHSE and TES-1 staff, relevant Kyrgyz government officials, subcontracting engineers, and American suppliers of instruments and equipment will be invited to participate.

1.3 Background on Kyrgyzstan

The section below briefly describes relevant geographic, social, and economic conditions in Kyrgyzstan. It also presents an overview of the energy supply and demand situation, including recent consumption and production levels.

Geographic, Social and Economic Background

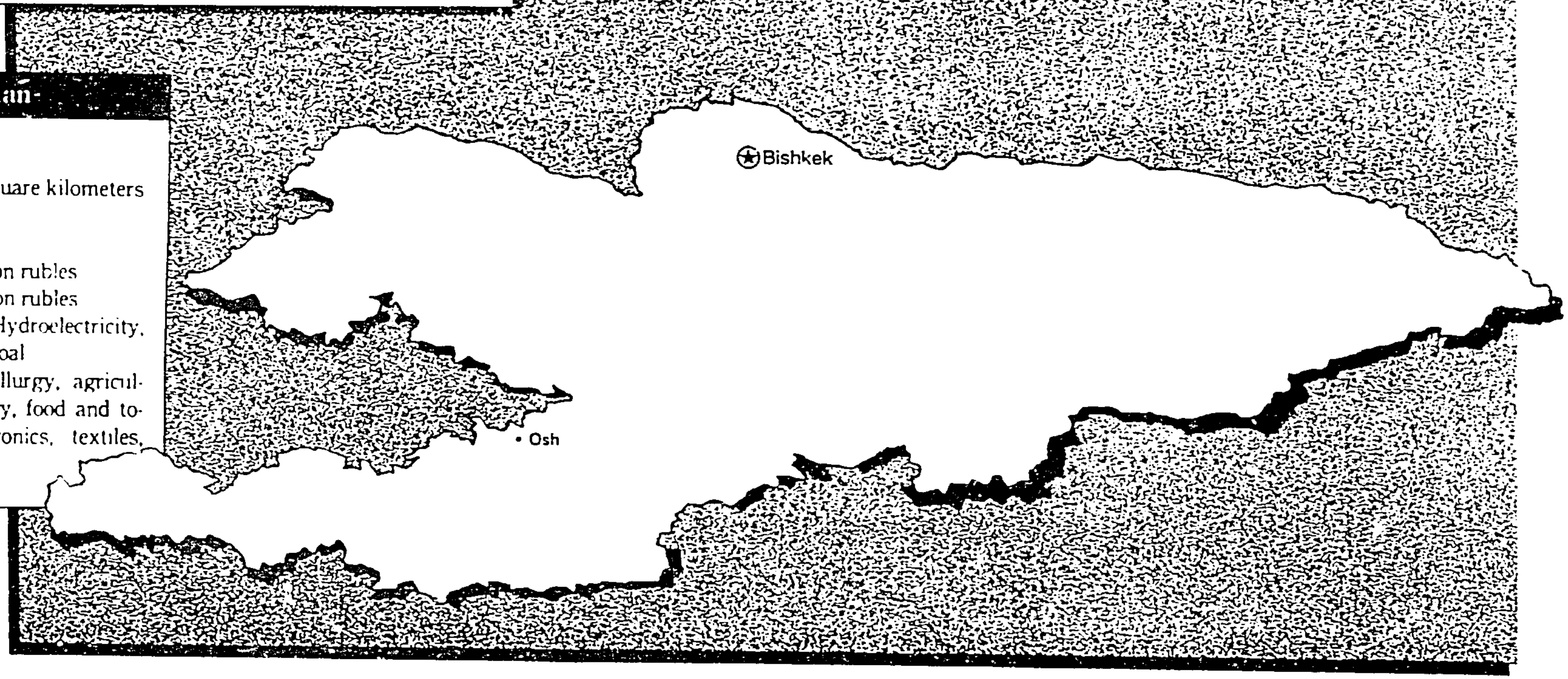
Kyrgyzstan, with a land area of approximately 76,640 square miles, has a population of 4.4 million. The republic is bordered by Kazakhstan and Russia to the north, China to the southeast, Uzbekistan to the west and Tajikistan to the southwest. A map which depicts the country and its location within the region and presents additional basic economic data is shown in **Figure 1** on the following page.

Major ethnic groups include Kyrgyz, comprising 52.4% of the population, Russians 21.5%, and Uzbeks, who make up approximately 12.9% of the total population. The second largest city is Osh is located southwest of Bishkek near the Uzbek border.

Figure 1.
Kyrgyzstan: An Overview

Kyrghyzstan

Capital: Bishkek
Area: 198.5 thousand square kilometers
Population: 4.4 million
GDP: 15.3 billion rubles
Total exports: 6.6 billion rubles
Total imports: 7.4 billion rubles
Natural resources: Hydroelectricity, gold, mercury, uranium, coal
Main industries: Metallurgy, agricultural and other machinery, food and tobacco processing, electronics, textiles, sugar refineries



Kyrgyzstan's major imports include machinery, light industrial goods, food, chemicals and petrochemicals, fuel oil, and natural gas. The country is a major producer of wool, livestock, and other agricultural goods.

The measure of economic growth as used in the NIS countries - Net Material Product (NMP), was 5.97 billion rubles in 1989, representing a NMP growth rate of 5.3% from the previous year.

Energy Supply/Demand

Estimates for 1992 energy production are included in **Table 1** below, with 1992 energy consumption data shown in **Table 2**.

Table 1. Energy Production Levels in Kyrgyzstan for 1992 (by fuel type).

Fuel Type	Production Level
Crude oil	2,500 barrels/day
Coal	2.2 million tons
Natural gas	68 million cubic meters/year

Source: Energy Program of Kyrgyzstan, 1992.

Table 2. Kyrgyzstan Energy Consumption (1992).

Fuel Type	Consumption Level
Oil and products	30,000 barrels per day
Coal	4.3 million tons
Natural gas	1.9 billion cubic meters
Electricity	9.7 billion kWh

Source: Energy Program of Kyrgyzstan, 1992.

Total thermal energy production for 1991 was 13,972,372 megawatt hours (mWh), which included 391,404 mWh from TES, and 10.05 million mWh from hydroelectric sources. Exports of electricity for the same year were more than 5.3 million mWh, making Kyrgyzstan a net exporter of electric power produced by hydroelectric sources. Together with its abundant coal resources, hydroelectric power has made Kyrgyzstan self-sufficient in electric power.

1.4 Audit Methodology and Scope

To accomplish the goals of the Energy Efficiency and Market Reform Project, the IRG Energy Audit Team developed a work plan which outlined the overall methodology and scope for the project; this plan determined that Team members would need to make four trips to the country. The first trip, involving the IRG Energy Audit Team Leader and A.I.D. representatives, served as a definitional mission. Team members conducted the energy audits during the second trip. The third trip allowed Team members to solicit comments on the recommendations and reports generated through the project, and to assist with equipment installation. In its fourth trip, the IRG Energy Audit Team will formally present the results of the project in a workshop format.

The energy audit of BHSE and TES-1 facilities, the focus of the Energy Efficiency and Market Reform Project, involved two major components: the system slice audit and the general (total system) audit. The "slice audit" refers to the process of monitoring, measuring, and conducting a detailed energy audit in representative installations within an energy complex (in this case, BHSE). These installations depict a narrow "slice" of heat production, distribution, and end-use facilities within the system, and allow audit specialists to evaluate direct energy use at specific points throughout the system. This type of examination enabled IRG Energy Audit Team members to draw broad conclusions about the entire system. Given the time and resource constraints of this project, the "slice audit" method served as an effective, efficient way to gain needed insights into the energy consumption practices through the entire BHSE system.

Members of the IRG Energy Audit Team also conducted a "general (total system) audit" using information from the "slice" audit, as well as data from plant management and operating staff, various plant records and statistics, and general observations and interviews. This broader audit provided an evaluation of overall energy use and broader management issues.

To facilitate this process, a detailed questionnaire developed by IRG Team members was translated and sent to BHSE prior to the actual audit. The questionnaire prepared the BHSE specialists for the audit program and allowed the IRG Energy Audit Team to collect data that would be difficult to compile during the short time allotted for the two audits. A copy of the questionnaire is included as **Appendix I** of this report.

1.5 Completed Activities

In March 1992, the IRG Team Leader, Gerald Decker, completed the definitional mission and submitting his observations and recommendations in the form of a trip report. His findings, as well as those of the A.I.D. representatives who also participated in the mission, served as the basis for the development of the audit methodology and project workplan.

The entire IRG Energy Audit Team travelled to Kyrgyzstan the following month to conduct slice audits of one heat production system, one distribution system, and three end-use installations. End-use facilities audited included an industrial installation, a commercial facility, and a multi-unit residential (apartment) building. Team members also held detailed discussions with representatives of BHSE and TES-1 management staff, key government officials, and relevant independent engineers.

At the end of the weak-long audit, Team members presented an informal energy management seminar, which focused on transferring Western techniques for the economic evaluation of energy investments and strategic planning. In addition, representatives of U.S. private-sector energy equipment vendors and project developers gave brief presentations on equipment and financing opportunities available to the country.

2. DESCRIPTION OF FACILITIES WITHIN THE BISHKEK DISTRICT HEATING SYSTEM

2.1 Heat Production (Power Plants/Heating Boilers)

In 1956, the Bishkek Heating System Enterprise began construction of a new heat and power facility with a primary capacity of 50 megawatts (MW) to satisfy the growing electrical and heating needs of the city and its surrounding districts. This facility, the Bishkek Thermal Plant (TES-1), was constructed on the eastern outskirts of town since many new industries with significant electrical demands were being located in this area; the Bishkek Wool Fabric Factory audited by the IRG Team was one such facility.

Construction began on the thermal plant in 1958, and due to the rapid increase in customer demand, construction of a second station (200 MW) was begun in 1960. The first turbine generator, a 25 MW facility, was commissioned in September 1961 and in 1962, a third line was incorporated to satisfy additional demand. When the last of the six turbines on the third line was completed in December 1962, the station's total capacity reached 410 MW. By 1968, TES-1 was producing 1.4 million megawatt hours (mWh) of electricity and delivering 1.607 million Gcal of heat to its customers. However, heat and energy demand increased at a faster rate than was projected, and tho capacity of these lines became insufficient the following year.

To meet the demand, a fourth line was built in 1973 and electric capacity totalled 674 MW. In 1981, a fifth line was designed, a 300-meter smoke stack was constructed, and four boilers with individual capacities of 220 metric tons (MT) per hour were added.

Since that time, TES-1 has led the energy development of northern Kyrgyzstan. The construction of the TES-1 plant, together with the installation of other heating networks, stimulated industrial development throughout the city. Construction of electric networks in the Chui Valley, the regions surrounding Lake Issyk-kul, and areas of Tjan-Shan, led to the expansion of the electricity network in both the urban and rural, agricultural regions of the republic. Consequently, the growth rate for contracted load of the northern Kyrgyzstan electrical system has averaged 15% to 17% annually.

2.1.1 Bishkek Thermal Plant

Most important within the TES-1 facility are its boilers and turbines. These boilers and turbines are primarily fueled by coal, mazut and natural gas for heat and power production. Boilers which burn coal are supplemented with Mazut combustion capability to compensate for the low heating value of the coal. Average low heating values (LHV) for fuels used within TES-1 are shown in **Table 3** on the following page. While coal and mazut are transported to the plant by rail, natural gas is furnished via pipeline.

Table 3. Average Heating Value of Fuels Utilized by Bishkek Thermal Plant.

Fuel	Heating Value (Kcal/kg)	Heating Value (Btu/lb)
Coal	3858	6900
Mazut	9530	17179
Natural gas	8097	903 (Btu/m^3)

Steam pressure is maintained at 10 MPa on all boilers within the system, with an average boiler temperature of 540° C. Fuel consumption for the BKS-130 and BKS-160 boilers averages 23.5 MT/hour, whereas for the BKS-100 boilers the average is 32.0 MT/hour.

Average cost figures for fuel inputs of TES-1 in 1991 are shown in **Table 4** and TES-1 energy production figures for 1991 are presented in **Table 5.**

Table 4. Fuel Input Prices for Bishkek Thermal Plant (1991).

Fuel	Price (Rubles)
Natural Gas	958/m^3
Coal	665/MT
Mazut	401/MT

Table 5. Energy Production for Bishkek Thermal Plant (1991).

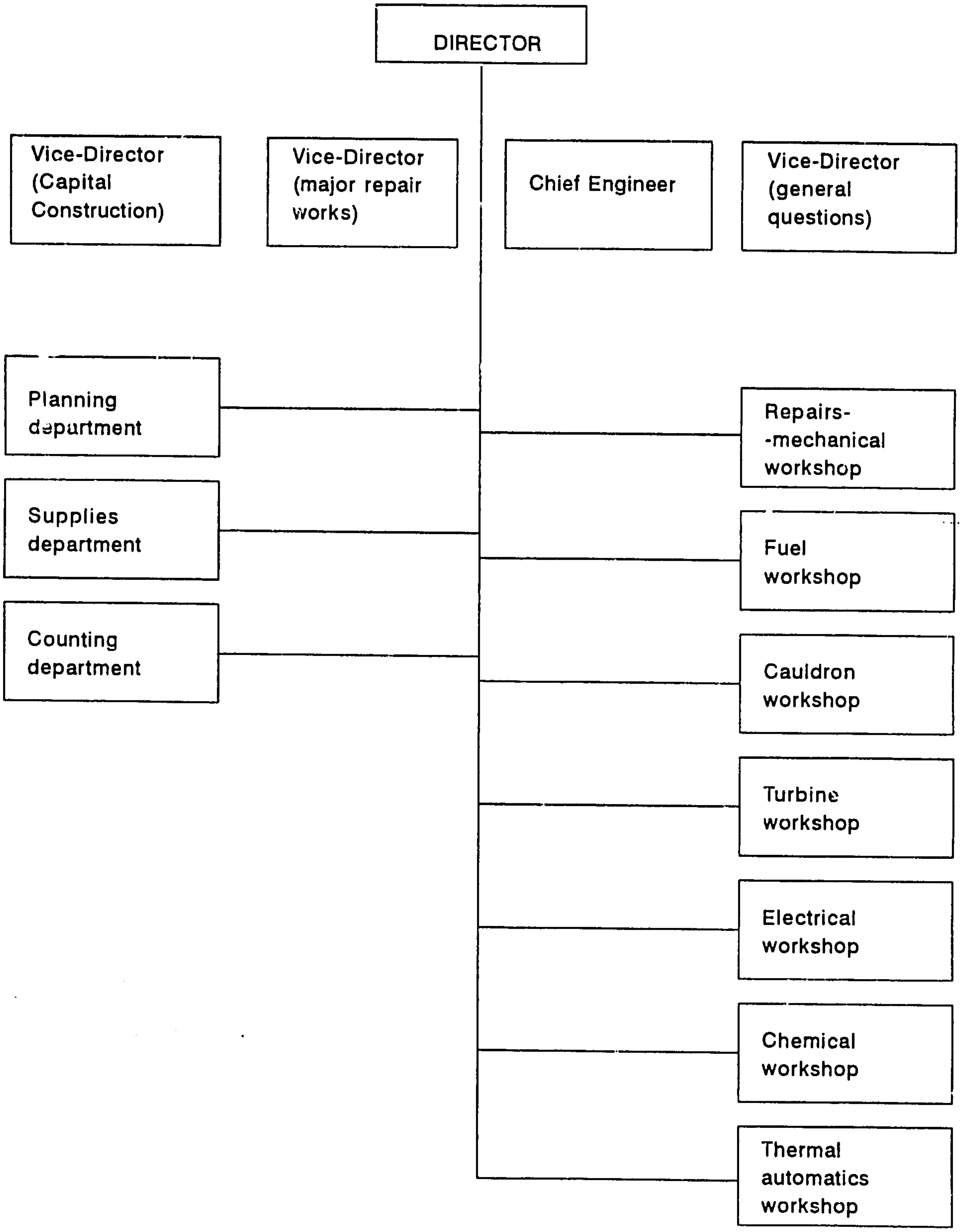
Energy Type	Production Level
Electricity	3,685,223 kwh
Thermal Energy - Steam	1,354,000 Gcal
Thermal Energy - Hot Water	3,006,000 Gcal

2.1.2 Management and Organization

Figure 2 depicts the general organization structure of the Bishkek Thermal Plant. The primary consumer of heat produced at this plant is BHSE. Primary customers for TES-produced electricity include "Kubat" Holding Company (Kyrghyzglavenergo), the parent company of both BHSE and TES-1.

Figure 2.

General Organization Structure of Bishkek Heat & Power Plant



2.1.3 Operation and Maintenance

Operation and maintenance of equipment at TES-1 is conducted by station workshop personnel and maintenance crews within the repair division. Repair personnel are then divided into the following functional subsections: (1) fuel; (2) boilers; (3) turbines; (4) electrical; (5) chemical; and (6) thermal & automatic controls.

Individual workshops have both operations and repair personnel. Operations personnel work in a two-shift mode -- for a total of four shifts, and provide routine technical support in addition to equipment maintenance. For both major and routine repairs, outside contractors may be employed, depending on the complexity of the repair. At the present time, 12 outside firms from the Bishkek area are contracted by TES-1 for regular repair and maintenance work.

2.1.4 History of Energy Efficiency Efforts

Prior to the April 1992 energy audit, a number of technical measures had already been implemented at TES-1 to improve the effectiveness of the equipment and overall reliability of the station. Similarly, the plant had already initiated several measures to improve general conditions of plant operations. Most significant among these improvement projects were:

- Transfer of turbines NN 3,7 and 8 to improve vacuum condition;
- Treatment of boiler feed water with di-phosphate acid;
- Reworking of turbines NN 4,6,9 and 10 to install thermal extraction systems;
- Reworking of Boilers BK3-160, and BK3-220 with two-step combustion systems to avoid excessive NO_x in the flue gas;
- Use of condensate from turbines NN 1 and 2 to heat boiler feed water;
- Installation of feeding headers on heat networks with vacuum deaerators;
- Use of boiler steam as a dispersement agent for mazut in the oil burners;
- Installation of venturi tubes on the wet ash scrubber in lieu of wall grids.

Bishkek Thermal Plant has also received approval and funding to modernize the outdated and worn equipment. As part of the funding provisions, a program to increase the reliability and economical efficiency of the plant is required. Although these efforts have not focused exclusively on energy efficiency, they demonstrate a clear understanding of the need to make overall operations more efficient and economical.

2.2 District Heating System

Bishkek, the capital city of Kyrgyzstan, is situated in the Chui Valley at the northern foot of the Ala-Too mountains. This city resides on an inclined plane which ranges in elevation from 700 meters to 900 meters above sea level. The population of the city is approximately 680,000 and its district heating system serves a total residential floor area of 8.5 million square meters (136 square feet per person). Single-level buildings account for 30% of all buildings, while those with 2 to 3 floors represent 7%, and 63% of all buildings have 4 or more floors. Prior to 1956, city heat was supplied primarily by boiler halls of a number of plants, as well as small, individual boiler rooms. As described earlier in this report, a new heat and power plant with a primary capacity of 50 MW was built in 1956.

The first 25 MW turbogenerator was put into operation in 1961. This is considered to be the beginning of centralized heat supplies in the city. In 1962, the workshop for the thermal system was organized and began to serve 0.4 km of heating networks, with an additional heating load of 3.3 Gcal/hour. Facing rapid increases in demand, the system enlarged the heat and power station (TES-1) and began the construction of the main hot water line. In 1963, the workshop became a district heating system. Since 1968, this system has become an independent enterprise.

Approximately 210 industrial enterprises have production facilities operating within the city limits. According to April 1992 statistics, consumers with heat loads of 1,540 Gcal/hour in hot water and 280 Gcal/hour in steam were supplied by the heat and power station (TES). BHSE also contributes about 500 Gcal/hour to this industrial group.

2.2.1 Management/Organization/Staffing/Customers

BHSE employs 399 individuals, including 312 technicians and 87 management and support personnel. There are six departments within the organization, including district operating, maintenance, repair, and measurement service divisions.

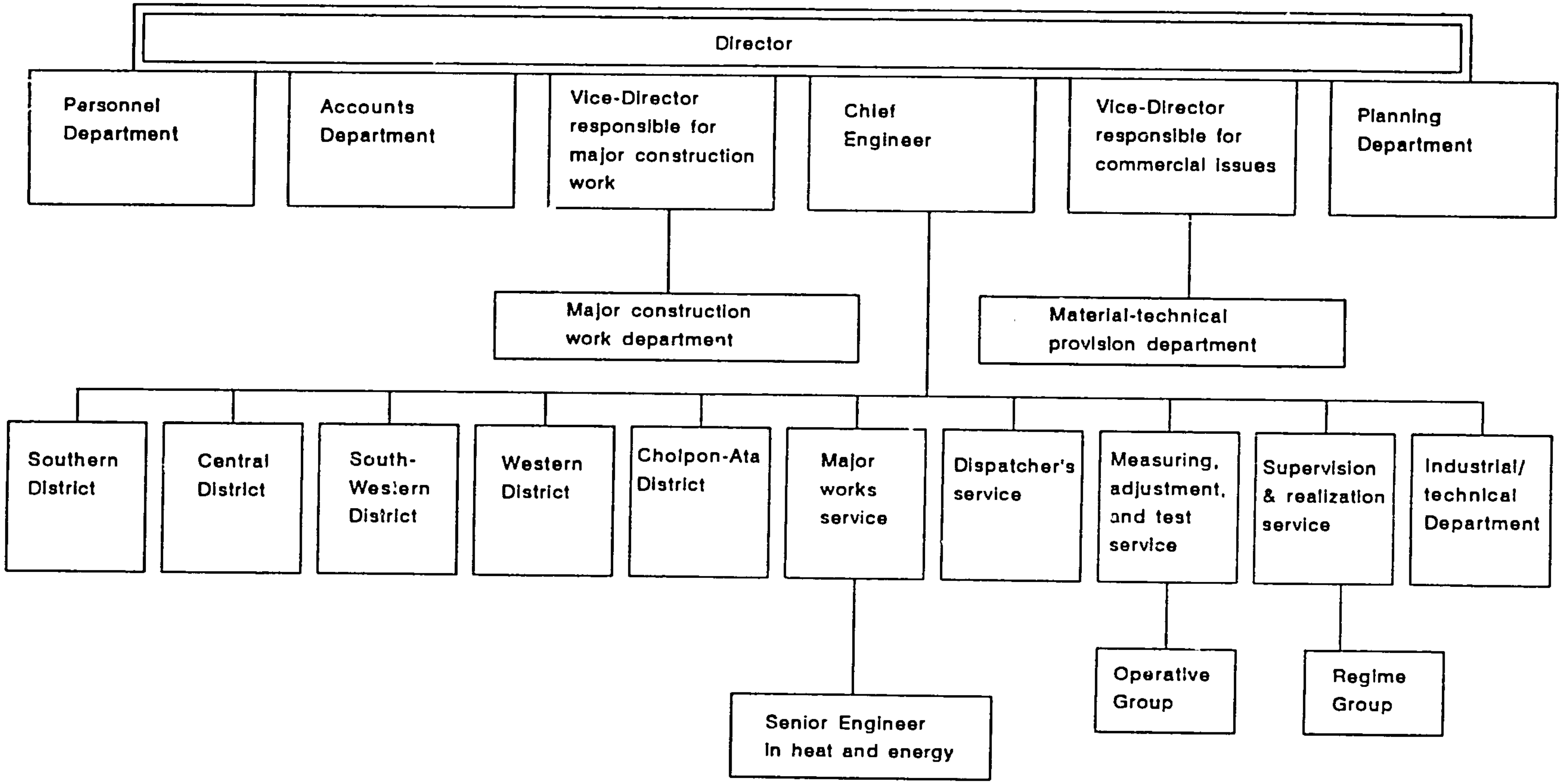
The district operating division is, in turn, composed of 182 employees, with 80 employees in the repair service subsection, 23 in the dispatch service subsection, 5 engineers in the industrial technical department and 12 engineers in the supervision and implementation department. An organizational chart of the BHSE system is presented in **Figure 3** on the following page.

2.2.2 Distribution System

There are 350 kilometers (km) of steel hot water pipelines within the district heating system; of this total, approximately 15% are located above ground and the remaining 85% underground. There is also a 33-kilometer steam network, composed of pipelines ranging from 33 mm to 900 mm in diameter. The age of this network ranges from 1 to 25 years. Replacement of pipelines previously laid 10 to 15 km of new pipeline each year, but only two km were replaced in 1991 due to lack of funding.

Figure 3.

Organizational Chart of Bishkek District Heating System



The district heating system operates 335 days annually, shutting down for 30 days each year between May and June to service the distribution system. Since this is an open-loop system, both space heating and domestic hot water functions are out of service for the city during that period.

Maps included in **Figure 4 (Sections A through C)** depict the main pipeline networks of BHSE. These networks are comprised of 10 heat exchanger stations which convert steam to hot water and 12 pump stations. The average rating of these pumps is 360 kw, with a flow of 100 cubic meters (m^3) per hour and a head of 10 atm. Pump motors generally operate at a constant speed of 1500 rpm, although there are pumps of several sizes on line at each station to allow the operators to combine these in ways to better match actual demand. **Table 6,** which depicts the distribution of heat delivery within BHSE, is shown below.

Table 6. Heat Delivery Distribution, Bishkek Heating System Enterprise

Sector	Number of Customers	Steam (kg/hour)	Hot Water (m^3/hour)
Industrial	235	270.69	202.68
Institutional	277		67.24
Residential	37	4.6	25.80

Rate of heat delivery varies from 62 Gcal/hour to 1,061 Gcal/hour, with an average of 556 Gcal/hour. The system has a rated capacity of 1,600 Gcal/hour. Maximum circulation rate in the system is 20,000 m^3 per hour, with an average rate of 16,000 m^3 per hour. Water make-up for the system is about 4,000 m^3 per hour, representing both consumption and leaks in the network. Steam is supplied to the network at a pressure of 8 to 13 atm, and temperature of 300° C. The temperature of hot water supplied can vary with the ambient temperature up to 150° C.

In addition to TES and the district heating system, the city of Bishkek uses more than 150 individual boiler rooms equipped with 660 boilers to generate 900 Gcal/hour of heat.

2.2.3 History of Energy Efficiency Efforts

Prior to the 1992 energy audit, BHSE staff had already developed a number of projects to increase the energy and operational efficiency of their system. Those projects initiated are outlined in **Table 7** on the following page.

Figure 4.
Main Pipeline Network
Bishkek Heating System Enterprise

Section A

Section B

Section C

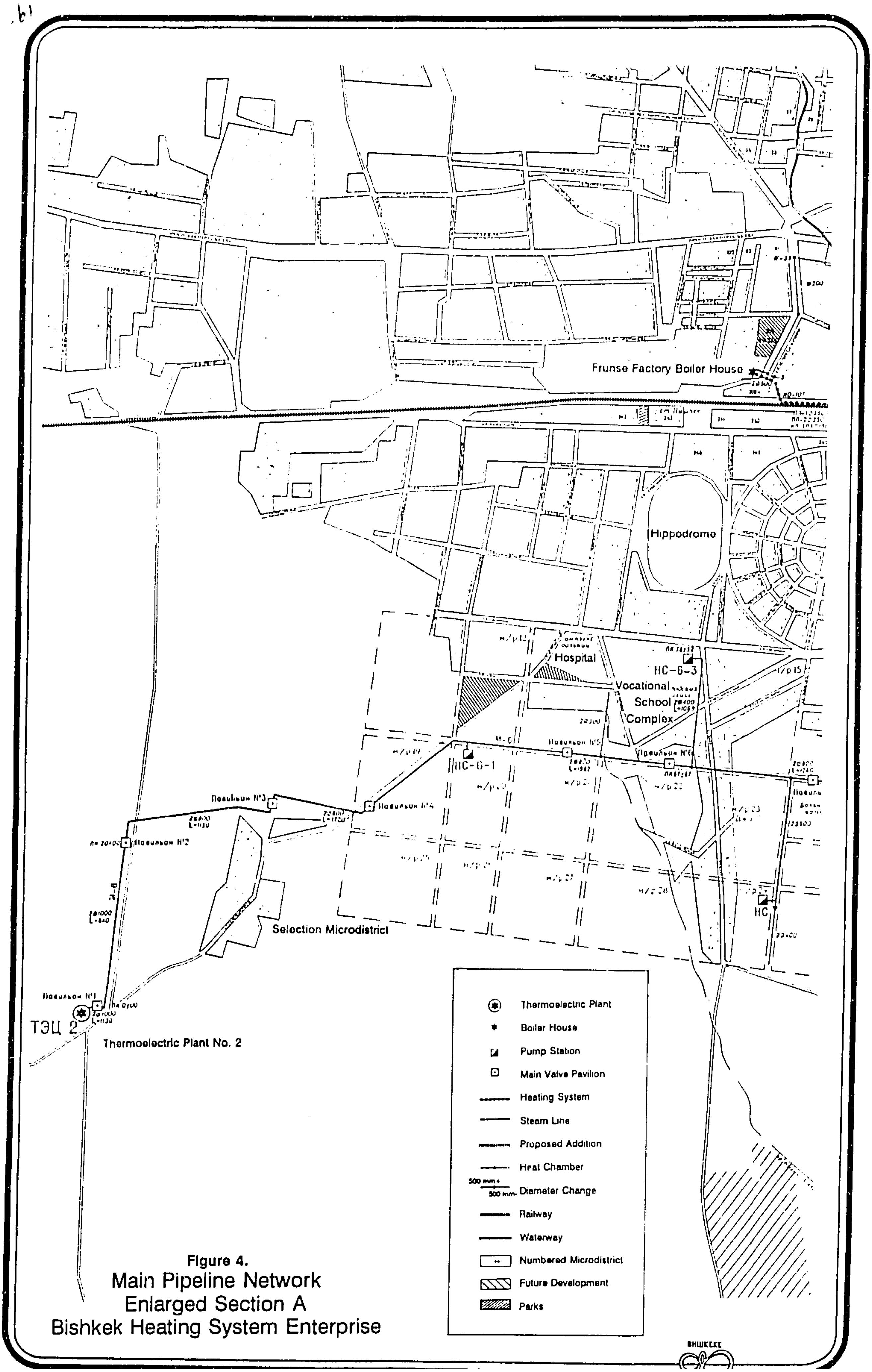


Figure 4.
Main Pipeline Network
Enlarged Section A
Bishkek Heating System Enterprise

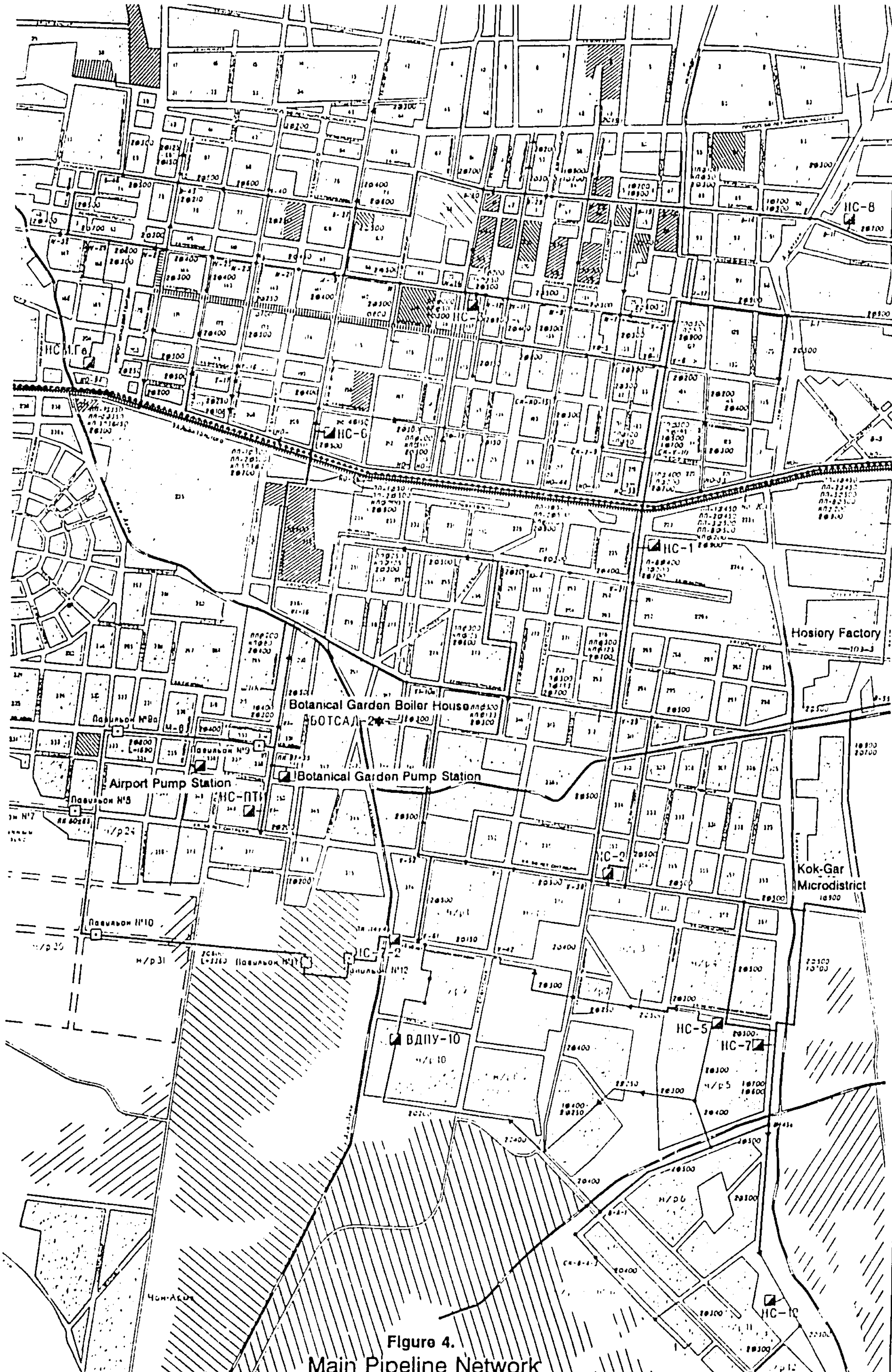


Figure 4.
Main Pipeline Network
Enlarged Section B
Bishkek Heating System Enterprise

20

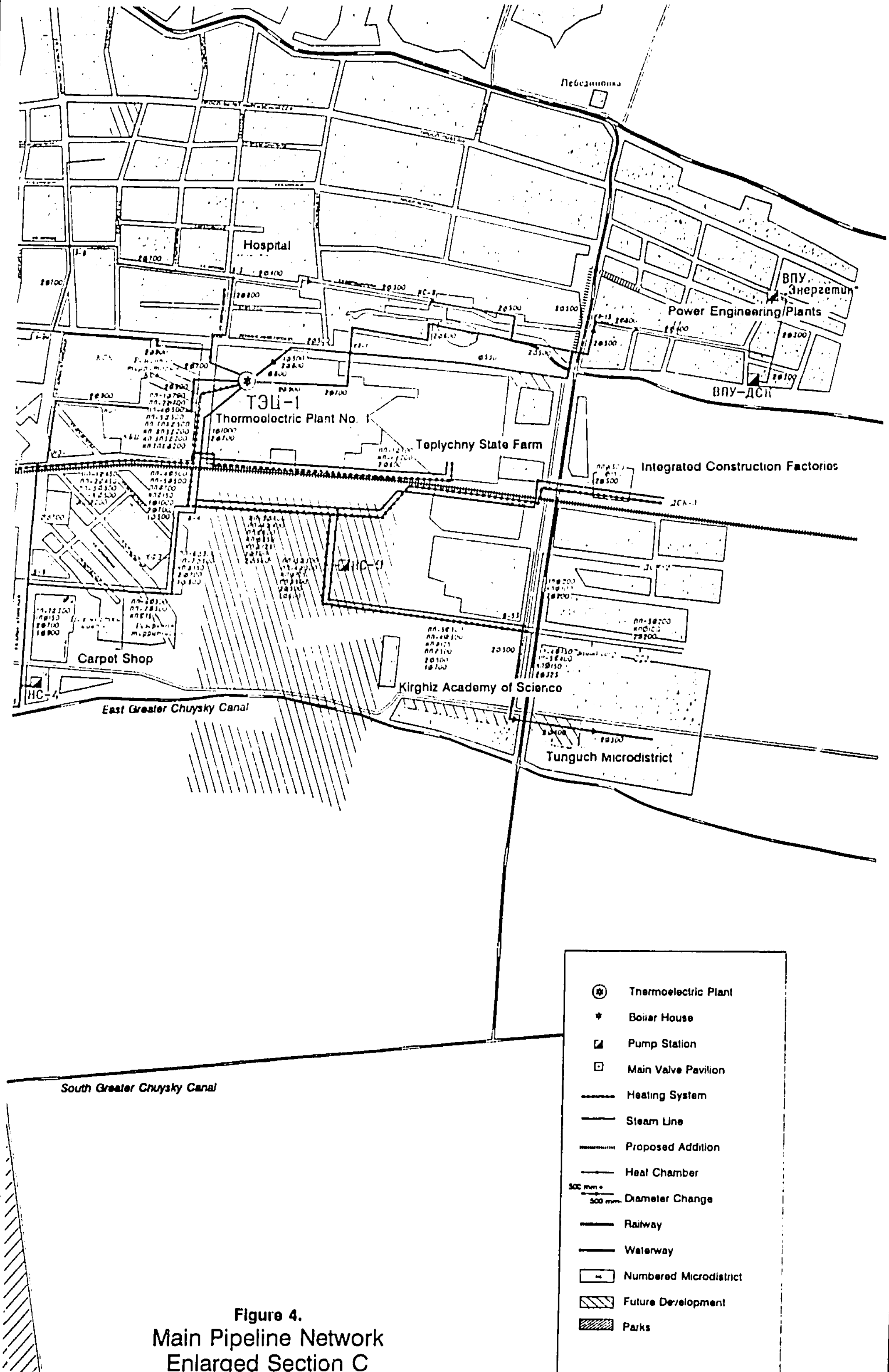


Figure 4.
Main Pipeline Network
Enlarged Section C
Bishkek Heating System Enterprise

Table 7. Proposed Energy and Operational Efficiency Projects, Bishkek Heating System Enterprise

Project	Cost (000 Rubles)	Potential Savings (Gcal)
Development and testing of hydraulic regime	270	3,906
Replacement of pipelines (20 km)	$7,150,000	3,000
Repair and restore insulation	3,000	820
Monitor heat energy in residential district 12	120	160
Develop summer hydraulic regime with zone regulation	6	150
Use new methods to detect water leaks in pipelines	200	740
Introduce pressure regulators on pipelines	300	700
Eliminate flooding by draining concrete chambers and conduits	200	1,420
Improve heat insulation system for accessories	750	835

2.3 End-Use Systems

This section discusses each of the following end-use systems present (industrial, commercial, and residential) in the Bishkek district heating system.

2.3.1 Industrial Customers

From the time of its establishment as the city's heating system in 1962, a number of individual industrial enterprises have been connected to Thermal Energy Station #1 (TES-1). At present, TES-1 services 180 industrial consumers, 70 of these purchase steam, and the balance hot water. The state-owned Tieplitshnyi greenhouse represents the single largest consumer of heat within this system, consuming 195,750 Gcal (132,340 Gcal in steam, and 63,410 Gcal in hot water) annually.

As a group, industries consume almost 75% of the total thermal energy output of TES-1. The maximum individual load is 130 Gcal/hour, while the minimum individual load is 0.02 Gcal/hour. Steam is used primarily in industrial processing, although it is also utilized to produce hot water at these sites. Load growth among of industrial consumers has been greatly reduced in recent years due to a lack of thermal capacity reserves at TES-1. In 1991, the growth in load was only 7 Gcal/hour.

The cost of thermal energy for industrial consumers in April 1992 was 268 rubles/Gcal. About 10% of the consumers have orifice type flow meters at their substations. Where there are no measuring device, estimated loads are used as the basis for customer billing.

Due to a lack of financial and technical support from outside sources, modernization and/or replacement of old, worn equipment and facilities has been rather limited. The result is that industrial facilities use outdated and inefficient equipment, as evidenced in these audits. Specifically, adequate energy measuring devices, flow meters, heat meters, regulators and controls are lacking throughout Kyrgyzstan. As a result, all efforts to improve energy efficiency over the last ten years have had limited success, following a basic tenet of energy management which states that, "If you cannot measure [energy], you cannot manage [it]."

Additional reasons why energy efficiency efforts have been unsuccessful in the past include (a) heavily subsidized energy costs, established by the government (until 1991) made energy inputs only a fraction of total production costs; and (b) the concept that users must pay for their consume was never established in these centrally planned economies. As such, individual metering of energy consumption was seldom practiced, with the state devising a formula for each customer to be billed based on their estimated consumption instead.

By necessity, the customers of BHSE will adapt to the market economy system as soon as the prices of electric power and thermal energy are adjusted upward, and individual metering is installed, allowing utilities to base customer billings on actual (as opposed to estimated) consumption. In reality, however, there are still many obstacles to implementing the optimal system, including technical, financial, and social considerations. Further discussion of this issue is contained in Section 4.

2.3.2 Residential Customers

Approximately 75% of the residential facilities in Bishkek receive their central heat supply from TES-1; nearly 395,000 citizens depend on this network for their space heating and domestic hot water needs. As with many TES-supplied industrial facilities, no measuring devices are currently used to monitor individual heat or hot water consumption by these customers. The maximum demand for both functions from this group is approximately 570 Gcal/hour, with an annual load growth in this sector of 40 to 45 Gcal/hour, or 7% to 9%.

Energy efficiency has never been a major consideration of the residential sector, since heating costs historically have been heavily subsidized, and since the nominal heating charges billed to customers did not reflect actual individual consumption. Energy-conservation strategies such as the addition of wall and roof insulation and the installation of thermal windows have never been considered as options for residential buildings, and combined with a policy which implicitly undermined individual incentives to improve energy efficiency, has resulted in a highly energy inefficient residential sector. As was the case throughout the former Soviet Union, residential heating was commonly "adjusted" by opening and closing windows.

3. DESCRIPTION OF AUDITED FACILITIES

3.1 System Slice Audit

This section details equipment within the production and peaking plant, distribution system, and end-use (customer) systems that were part of the system slice audit.

3.1.1 General Description and Scope

The IRG Energy Audit Team conducted a system slice audit of BHSE by visiting selected generation, distribution, and end-use installations within the system. Specialists from BHSE and TES-1 assisted Team members with the audit. To facilitate evaluation of the system, Team members divided transmission and end-use installations into three groups for more detailed examination. Team Leader Gerald Decker inspected the steam and hot water boilers at the mixing station; Tadeusz Swierzawski analyzed the main pump facility at the mixing station; and Frank Wang and El Oliker inspected representative sites of BHSE industrial customers.

3.1.2 Production and Peaking Plants

One boiler, one turbine, and one heat-exchanger station were selected for system slice audits by the IRG Energy Audit Team. Since all 24 boilers and 10 turbines of the system are similar, a complete audit of all flows, temperatures, and pressures, as well as an examination of the control room of the power station, provided Team members with an accurate analysis of the plant.

At first glance, the boiler combustion flame appeared to be in good shape; upon investigation by the IRG Energy Audit Team, however, an excessive amount of air was discovered, confirming a need for oxygen analyzers. Team members also observed several inspection doors were open, allowing additional air to leak into the boiler.

Team members measured air temperature both entering and exiting the heater, at combustion chamber inlets, and boiler surface temperatures. These measurements are given in **Table 8** below.

Table 8. Relevant Temperature Measurements Taken of TES-1 During the 1992 IRG Energy Audit

Type of Measurement	Temperature Reading (° C)
Air entering boiler pre-heater	50
Air after pre-heater	150
Hot air to boiler	184
Steam line, outside of insulation	60.6
Steam line, no insulation	144
Hot water outlet temperature	61.5
Return water temperature	44 **
Main turbine bearing	57
Thrust bearing	40.1
Boiler surface	45

** below sanitary safe temperature

Steam Boiler Area

Upon examination of the steam boiler area, Team members noted housekeeping could be improved, realizing the use of coal with an ash content of 40% has made it difficult to maintain a clean boiler room. Insulation on the boiler surfaces was generally in good condition; the boiler environment was not hot, indicating adequate insulation performance.

Boiler/Turbine Control Room

The boiler/turbine control room operates without many of the instruments normally found in Western plants due to lack of funding. System components most in need of control are boilers, turbines, and heat exchangers. These represent important areas of improvement for this facility, even though investment in adequate controls will require more money than is available within the plant's operating budget or through donor financing. These areas of concern should be seriously considered in future projects.

Boiler Stack Area

Since all boilers discharge their flue gases into a single 300-meter stack, it is difficult to identify gases from individual boilers. Without the ability to monitor flue gas emissions from each boiler, it is further impossible for plant maintenance staff to determine which boilers are operating efficiently, and which may need repair or adjustment. This is an additional reason to equip each boiler with oxygen analyzers to achieve the optimal combustion.

3.1.3 Distribution System

BHSE manages both the thermal energy generation plant and distribution network which the IRG Energy Audit Team examined during their April 1992 audit. The distribution network includes 10 stations which exchange steam to hot water, which are primarily located near industrial users. To keep hot water circulating within the system and to overcome the 200-meter elevation differential within the Bishkek district, 17 booster pump stations were constructed. These stations are comprised of a total of 100 pumps, each with a pressure head of 100 meters of water (approximately 10 atm). These pumps maintain a constant speed of 1,500 rpm and consume 360 kw each. Every third pump is parallel and serves at different flow rates so operators can switch and combine pumps to match the demand variations throughout the season.

Hot water pressure ranges from 8 to 10 kg/cm^2 at the supply end and from 2 to 7 kg/cm^2 at the return. Although there is no diesel powered pump within the system for emergencies, all pumps are electric powered, with two main feeder lines for power supply as a safety measure.

Insulation

Insulation within the distribution system is required for the 318 km of hot water pipelines and 33 km of steam lines; approximately 15% of the total pipeline network is above ground and the balance underground. The steam temperature at the supply end ranges from 290° to 300° C, allowing for a drop in temperature of 130° C as it travels through the system, the steam temperature at customers' receiving end is maintained at 160° C.

Insulation used in the BHSE distribution system is manufactured from mineral wool, with a fastener system which uses metallic net. As with similar systems throughout the former Soviet Union, drawbacks to this method include loose coverage of insulation, air pockets, missing insulation around valves, damp insulation, and reduced efficiency in underground pipes (i.e., the insulation is not protected from water).

System Leakages

Leaks within the distribution system are detected primarily by visual inspection or discovery of a loss in water pressure between two or three node points. Further, the ability to detect such losses using these methods is limited to major leak sites; the facility has no provision nor instruments to monitor small leaks. Since the pipelines are constructed of steel, pin hole leaks are difficult to detect without sophisticated instrumentation.

Controls

There are both temperature and pressure controls for distribution system control. All controls are manually operated with the exception of emergency and protection devices, which are automatic. The response time for manual controls is so slow that corrective actions are invariably too late. Management staff estimate that fuel energy savings of 3% to 5% can be realized if an automatic control system is installed.

The pipeline network is designed in such a way that if any major break occurs in the hot water loop it could cause an interruption of the whole distribution system. Such an interruption would be a major disaster were it to occur during the winter heating season; therefore, management considers the reliability of the system to be top priority.

Make-up Water for System

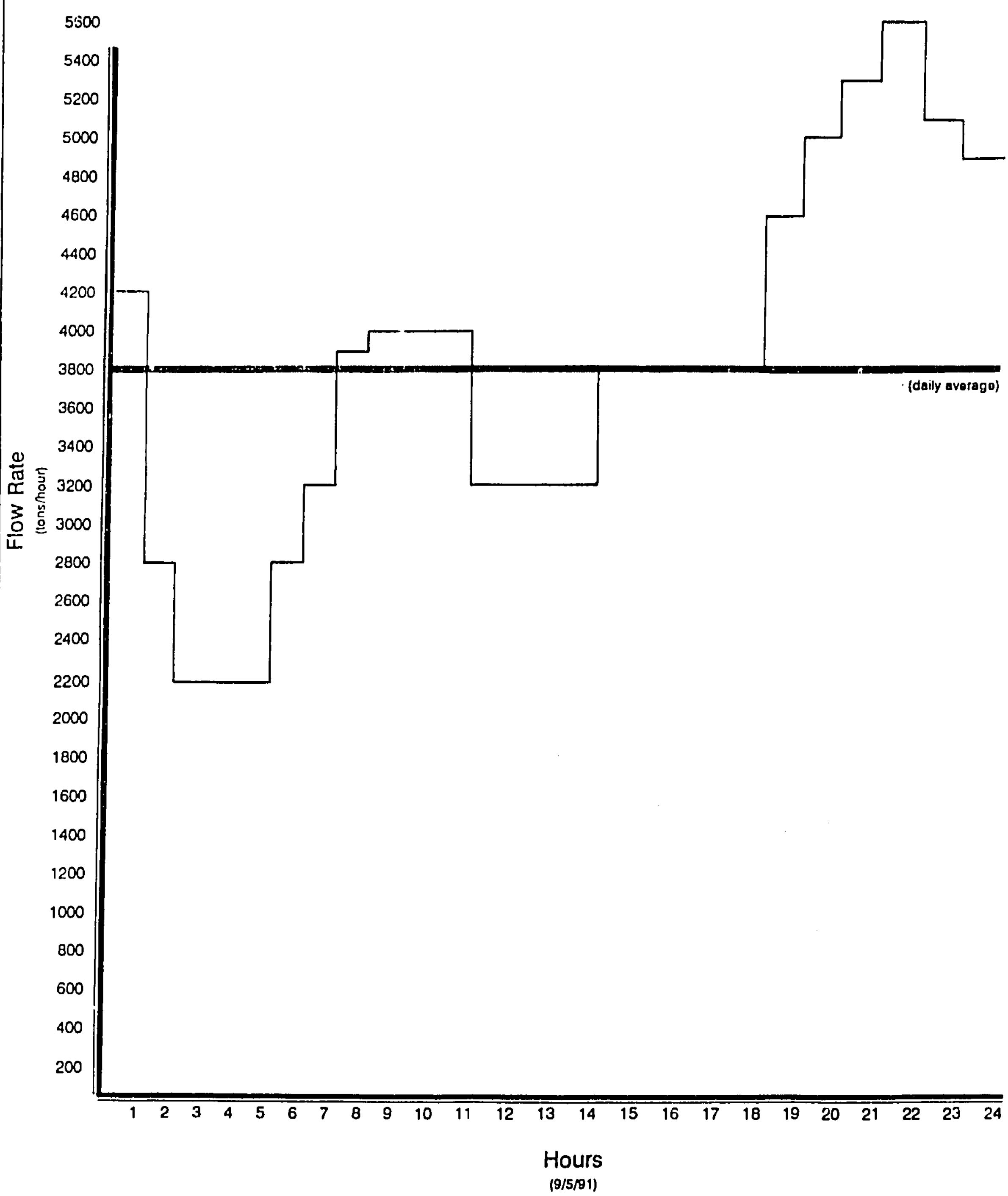
Since this is an open system, make-up water represents the sum of domestic consumption and leakage. The best estimate given by the management is that about 5% of the total make-up water utilized is due to leaks in the system. The yearly demand for make-up water was 31.72 million m^3 in 1991 and 32.21 million m^3 in 1992. The annual increase was about 6%. Therefore, the make-up water demand for 1993 is projected to be about 33 to 34 million m^3.

Upon examination of monthly demand records for 1991 and projections for 1992 below, the greenhouse group showed the least demand for make-up (hot) water, and the general population group showed the highest demand due to domestic consumption. Specifically, Figure 5 details the hourly variation of make-up water demand for a specific date in September 1991. Note that the system's minimal demand, 2200 m^3/hour, occurred between 2:00 and 5:00 a.m., and its maximum, 5600 m^3 per hour, occurred between 9:00 and 10:00 p.m.

The costs of treated water for hot water and steam customers are quite similar; as of the April 1992 audit, the price of steam was 3.26 rubles/m^3 without condensate return, and 1.68 rubles/m^3 with condensate return. There has been a substantial increase in the cost of hot water or steam for industrial customers. Approximately 53% of the total thermal energy delivered is consumed by residences, apartment houses, schools, and institutions, which are heavily subsidized by the government.

Figure 5.

Flow Rate Hourly Curve
Make-Up Water Demand



3.1.4 End User (Customer) Systems

The following sections present information collected during the representative slice audit of end-use (customer) systems conducted by the IRG Energy Audit Team. These include discussions on the industrial, commercial, and residential facilities selected, and includes data on each facility's insulation, system leakages, and monitoring and control facilities, as well as temperatures taken throughout the system.

1. Industrial Customer: Bishkek Wool Fabric Factory

This factory was selected by BHSE for inclusion in the April 1992 IRG energy audit and is illustrative of the system's industrial customers. This plant was established in 1964, and produces all kinds of wool and wool-blended fabrics for domestic use and exportation. The factory was state-owned until January 1992, when it became a share-holder owned enterprise. The state still currently holds 51% of the enterprise, with 49% owned by private parties. Workers at the plant may also purchase shares at rates lower than the state-established share price. For example, workers can purchase 1,000 Rubles worth of stock for 200 rubles, effectively an 80% discount.

The wool plant is divided into four primary operation units, which represent the four major steps of fabric making. These semi-autonomous units are organized under the overall organization of the plant. Products from the factory include various types of wool fabrics and fabrics made of wool/synthetic fiber blends. These textiles are ultimately used for the manufacture of dresses, suits, and coats of all weights, which are also produced within the plant. Approximately 45% of the fabrics are eventually manufactured into children's apparel.

Steam and/or Hot Water Usage

Hot water is primarily used for space heating and domestic consumption within the plant, but is also used in the washing and dying of wool. Steam, on the other hand, is used to dry the wool, treat fabric, and to humidify the fabric shops. Both hot water and steam are introduced at the substation through two lines each 270 mm in diameter. Technological steam is purchased from the cogeneration plant at 10 to 12 Kg/cm^2 during both the summer and winter. Steam pressure within the plant is about 5 to 6 Kg/cm^2. Condensate return is estimated at 50%, and the condensate line is 138 mm in diameter.

The plant has two primary steam lines that are 270 mm in diameter and 580 m in length, as well as one condensate line that is 138 mm in diameter and 580 m in length. Hot water under a pressure of 5 Kg/cm^2 and a temperature ranging from 70° to 130° C (summer and winter) is received at the substation. Hot water pressure is 8 Kg/cm^2 at the supply, and 7.0 Kg/cm^2 at its return, while its temperature ranges from 60° to 90° C (summer and winter).

There is also a heat exchanger station at the substation which converts steam energy into hot water thermal energy. During the summer when hot water is not needed, the heat exchanger station uses steam to make hot water for both wool processing and domestic consumption purposes. The station does not, however, have sufficient capacity to cover both space heating and process needs in the winter; another station utilizes the heat from the condensate return to make hot water for space heating. Cold condensate is collected in special condensate tanks and is then returned to TES-1 by pump.

Hot water for both these needs is prepared in the first stage heaters (i.e., heat comes from factory condensate to the heat exchanger). In the second stage, hot water of 30° C is heated until the temperature reaches 70° C for domestic hot water and 70° to 90° C for the process water. At the time of audit, this process for hot water conversion for space heating was inactive, but two heat exchangers were activated to convert steam to hot water. There is a pressure reduction station which drops the steam pressure from 10 to 12 Kg/cm^2 to half that amount. However, there is no steam turbine to take advantage of such pressure drops.

Steam and Hot Water Tariffs

Rates of hot water and steam tariffs are presented in **Table 9** below.

Table 9. Steam and Hot Water Tariffs at the Bishkek Wool Fabric Factory

Dates	Price (Rubles/Gcal)
Prior to January 1990	8
January 1990 - March 1991	12
March-June 1992	268
July 1992-January 1993	824
February 1993	9550

Consumption data, as estimated by BHSE and based on billing records, is shown in Table 10.

Table 10. Bishkek Wool Fabric Factory - Steam and Hot Water Consumption

	Max. Heating Load (Gcal/hour)	Process (Gcal/hr)	Ventilation (Gcal/hr)	Domestic Hot Water (Gcal/hour)
Steam	17.4	12.0	1.0	4.4
Hot Water	13.4	6.1	7.1	0.2

Total steam consumption at the plant is 101,331 Gcal/year, while the total hot water consumption is 23,919 Gcal/year.

Insulation

Insulation on the above-ground portion of the steam and hot water pipeline network is composed of either rock wool or urethane foam, with a covering made up of flexible sheets of aluminum. There are many sections of these pipeline networks which show poor insulation coverage; most visible pipes have insulation in place, but poorly installed coverage sheets leave the material exposed to the elements.

Leakages

There are no visible signs of hot water leaks within the plant; this does not mean, however, that the plant is leak free. At the time of audit, the heating season was drawing to a close and most water lines for space heating were inactive.

There are places where steam appears to escape within the processing and drying shops. In those areas, however, steam is injected into solution tanks to keep the temperature of the dyes constant. A mixture of steam and hot water is then sprayed into the air to humidify the conditioned air in several shops where fabric quality and workability are sensitive to humidity.

Controls

At the receiving stations for hot water and steam, both utilities are metered for flow rates, temperature, and pressure. Attendants manually record such data in the log book on an hourly basis, and manually adjust the flow rates of both the steam and hot water feeding lines in response to the demands placed upon these lines supplying various shops. Instruments are quite old, and there is no submetering.

Air Conditioning for Fabric and Fiber Shops

There are 40 air conditioning units in the plant, with individual air-handling capacity ranging from 20,000 to 120,000 m^3/hour. The average capacity is 80,000 m^3/hour, and an average electric rating for each unit of approximately 100 kw. Thus, total electric load for air conditioning is 4 MW. It is further estimated that 20% of the total 1991 electricity demand of 39 million kwh of was expended on these systems. While current air conditioners are extremely old, significant potential exists for savings in electricity through the replacement of such systems.

Energy Efficiency Measures to Date

Outdated, inefficient equipment is present throughout the plant. Unless electricity and thermal energy tariffs are increased to reflect world market prices, it is difficult to seriously consider modernizing plant equipment. This is especially true now, when there is little hard currency available for capital improvement. If a set of new instruments were installed at the substation to measure water, steam, and heat flow rates, consumption may not show much improvement as each individual shop user is not metered. However, BHSE estimated overall billings should be reduced by about 10% to 15% from the current billing of 1,000 Gcal/hour.

A firm from Almaty, Kazakhstan, was commissioned to design a strategy for re-piping the hot water feeding system to individual shops. As it is currently, it would require approximately 40 consumption meters to individually monitor and record steam and hot water usage within each shop. If such systems were installed, total consumption of both steam and hot water would be reduced by approximately 30%.

Steam Traps

The plant has experienced serious problems with steam traps. According to the Chief Engineer of BHSE, 9 steam traps are needed in the substation alone, where the capacity ranges from 1.4 to 1.8 MT/hour. Overall, 73 steam traps are needed for the plant which could provide a capacity ranging from .035 to 1.15 MT/hour, diameters from 15 to 50 mm and an average pressure of 16 Kg/cm^2.

2. Commercial Customer: Tieplitshnyi Greenhouse

This greenhouse began operation in 1972 and increased in size as the population of the city grew. The greenhouse currently consists of 24 hectares of glass-covered greenhouses, is divided into four independent sections, and is located in near TES-1. Although currently a government, it is in the process of privatization, and has been valued at 120 million rubles (January 1992). There are 600 workers, primarily female, employed at this enterprise. The greenhouse operates year-round, running two 12-hour shifts.

The heating season for the greenhouse is 10 months per year since some crops demand a temperature of 18° to 30° C. This temperature range is maintained via a central substation which receives steam and hot water from the district heating system. The substation is operated in three modes:

- the substation receives hot water from district heating system, which is then utilized for heating;
- when hot water temperature from the grid is not high enough, the substation steam-heats the water to the desired temperature; or,
- if there is no hot water supply available from the grid (such as during the May/June change over for the district heating system), steam is used to heat substation hot water, and a closed loop system is created. According to management, this mode is the most efficient.

Steam from TES-1 is fed to the central substation at a pressure of 10 Kg/cm^2. The steam pressure is reduced to 5 to 6 Kg/cm^2 for in-house usage. This reduction in steam pressure could be utilized to run a small, steam turbine-driven pump for the water circulations, but it has not been utilized to date due to inexpensive electric power from the grid; and high capital costs for start-up.

Steam and Hot Water Tariffs

The tariff cost for heat was 12.92 Rb/Gcal after January 3rd, 1992, with prices rising regularly. The cost for steam is the same, while the cost for electricity was 0.51 Rb/kwh at that time.

Insulation

Generally, the insulation is in good condition.

Leakages

Steam and hot water leaks do not pose a major problem.

Controls

Controls for flow rates and temperature of the greenhouse are old but in working condition.

3. Residential Customer: Multi-unit (Apartment) Buildings

An attempt was made to select two identical apartment buildings for purposes of conducting an audit of energy savings with the proper measuring and monitoring devices. Both buildings were constructed in 1963 and have the following similar characteristics:

- walls are constructed of concrete panels, and each building has four floors and a total of 48 flats, (12 one-bedroom, 12 two-bedroom, and 24 three-bedroom apartments).

- The buildings both have a two-pipe heating system; heating loads are estimated at 145,715 Kcal/hour. Domestic heat load for hot water is 164,000 Kcal/hour (estimated) for a heating season of approximately 180 days.

- Each building has a total of 226 radiators; diameters of the supply and return pipes to these radiators are both 1/2 inch (or 12 mm). Hot water is supplied from the district heating system to the building substations through a pipe 59 mm in diameter. Domestic hot water is taken from the hot water supply line in the house substation.

The substations of both buildings have the following instrumentation: supply water pressure gauge; supply water temperature gauge (thermometer is removed); water filters; and pressure gauges after the ejectors. There are also two pressure gauges and a filter on the return pipeline.

3.2 General (Total System) Audit

Energy losses within the district heating system are primarily caused by:

- Water leaks. BHSE is an open loop district heating system, making it quite difficult to distinguish the amount of water lost due to leaks from the water consumed by various domestic utilities. The IRG Energy Audit Team learned that estimated water losses due to leaks total approximately 300 m^3/hour under normal conditions, or less than 10% of the total make up water of 4,000 m^3/hour. Considering the age of the pipelines and the large number of booster pumps needed to overcome the elevational changes (i.e., higher pressure within the pipes), however, actual losses may be much higher.

  Identification of water leaks could be accomplished through:

  - Visual inspection;
  - Monitoring ground surface temperature with infrared thermometer/thermalvision;
  - Monitoring pressure drops between sections;
  - Monitoring flow rate between sections;

  It is extremely difficult to detect small leaks in any large pipeline system. Thus, Team members suggested the use of hand-held infrared thermometers to detect the ground temperature of areas where pipelines are buried. These same instruments can be used to detect heat loss and inadequate pipe insulation on the above ground pipelines as well.

- Failure to meter individual energy usage (industrial, commercial, and residential). In Kyrgyzstan, only 10% of the industrial users have orifice-type flow meters to measure the flow rates of hot water and steam. All other users are generally charged a flat rate for heat, resulting in lack of incentive to conserve energy. Many customers regulate temperature by opening windows, even in the middle of winter.

- Inadequate insulation. The presence of damaged or inadequate insulation is relatively common within this system. Trouble spots in the insulation could be readily detected along exposed lines through the use of an infrared thermometer.

- Throttling of constant-speed pumps. In Kyrgyzstan, constant-speed pumps are commonly utilized by the district heating system. To serve varying load conditions, two or three different-sized pumps are often installed in parallel; thus, by using combinations of different-sized pumps, variations in load can be approximately matched with pump station output. Between these combinations, however, flow rates are controlled by throttling the pump, resulting in wasted pumping energy.

Considering the size of the Bishkek distribution system where more than 100 pumps are installed in 12 pump stations, the total electrical load is about 36 MW. Through the use of variable speed pumps, a 10% savings would translate into 15 million kWh per year. At a cost of $0.06/kWh (the average U.S. price in 1991), the dollar value of such savings would be approximately US $1 million per year.

- Excessive changes in pressure. Any obstruction in the distribution system can cause excessive pressure drops and waste pumping energy. Obstructions can be accidental, gradually formed, or the result of faulty design (inadequate valves, under-sized pipe, excessive fittings or by-passes etc.). The pressure drop could be measured through pressure-sensitive gauges installed at appropriate points along the distribution lines.

It should be acknowledged that savings could result from the introduction of relatively inexpensive and effective modifications to the thermal energy generation plant; these would include the installation of oxygen analyzers, condenser tube-cleaning systems and steam traps. Such additions would produce greater savings, in a shorter period of time, than would proposed improvements to the district heating system.

4. FINDINGS AND RECOMMENDATIONS

4.1 General

This section presents the overall findings and recommendations of the IRG Energy Audit Team.

4.1.1 Boilers

Few boilers are equipped with oxygen analyzers to monitor excess air flow; this is an area in which combustion efficiency can be greatly improved. The use of these oxygen analyzers is especially critical when boilers are capable of using more than one type of fuel as in the case of the AHSE complex, where boilers can be fired by either natural gas or mazut.

4.1.2 Insulation

Insulation around the pipelines was found to be in poor condition in many sections, and in several instances, missing altogether. One major problem is the capability to securely attach insulation onto these pipelines.

4.1.3 Instruments and Measurements

A minimal number of instruments and automatic controls are available in the district heating system. Those that are available are quite old, either needing repair or re-calibration. Without instruments which function properly to monitor and record such essential variables as flow rate, temperature, and pressure, it is difficult to accurately determine balance measurements and conduct effective energy-efficiency analyses, on which overall plant performance should be based.

4.1.4 Cost Accounting and Performance Criteria

Although management staff are knowledgeable about the use of capital-cost analyses - as indicated by the previous emphasis on new construction - the lack of modern instruments to accurately measure and monitor heat flows at different levels of the system makes it difficult to complete such a detailed analysis. There is also a serious lack of plant performance criteria based on operating costs (and savings); management should institute such a directive.

4.1.5 Long-Term Energy Outlook and Policy

One factor which may make focusing on energy conservation and efficiency issues difficult is that government pricing subsidies are complicating the transition from a centralized to a market-based economy. The current energy situation in Kyrgyzstan bears strong similarity to that of

Eastern and Central European countries in the sense that energy resources have been dependent on other republics [within the NIS].

A second factor complicating this shift is the question of a common currency among the NIS republics (i.e., Rubles). Whether the NIS remains an economic commonwealth sharing the same currency is uncertain at this time; the fundamental desire of each republic, however, is not to be economically dominated by Moscow. To this end, the Republic of Kyrgyzstan issued its own currency, the som, in May 1993.

Assuming these individual currencies are created, the process of world market prices on energy resources may be realized sooner than otherwise expected. This is due to the fact that Kyrgyzstan relies on other republics for natural gas, coal and fuel oil. The indigenous production of these fossil fuels is only a small fraction of their total consumption. In due time, the republics supplying these fuels will demand not only that they be paid in hard currency, but at, or near, world-market prices.

Compounding the potential for economic hardships is the fact that the electricity and heat consumed by Kyrgyzstan has been subsidized not only by their government, but to a greater degree, by other republics who have been supplying them with energy resources previously. As a result, the country will undoubtedly encounter double difficulties. The timing, as well as the magnitude, of energy price increases may not be controlled by the government, and it is difficult to formulate any specific strategy to ease the transition from government subsidy to free market when the price of energy resources is dictated by other countries.

The long-term energy resource of Kyrgyzstan is definitely hydro-electric power as the country has the potential to produce more than 14,000 MW of hydro-electric power. The government is anxious to attract foreign joint venture partners to develop such potential. Detailed information on this power potential was not gathered in this mission.

4.1.6 Underlying Social and Economic Problems

Most industries are currently running in deficit and, subsequently, district heating systems are operating at a loss. As a result, the government is subsidizing industry. Industrial operations want to increase their energy efficiency to cope with existing and/or future price increases. However, improving energy efficiency entails modernizing facilities and implementing new production processes, since current facilities and production methods are already outmoded by Western standards.

Heavy capital investment will be needed to upgrade industries to be competitive in energy efficiency and productivity. Until industry achieves this level of efficiency, it will be difficult to pay for energy at prices approaching world market levels. On the other hand, without the existence of world market-level energy costs, industry will not attract the necessary capital investment.

4.2 System Slice Audit

This section covers both the heat production and distribution segments of our audit.

4.2.1 Concept of Free Market System

There is a strong need to have the middle management of both BHSE and TES-1 learn the simple fundamentals of a free-market system; they are entirely unfamiliar with cost accounting procedures and practices. Many are unaware of the true cost of energy resources, and what the market price of thermal energy should be. It is also unclear if management fully understands the far-reaching effects of world price levels.

Their current, fundamental concerns focus on a mixture of price increases and job losses. They need to understand that temporary suffering and hardship are unavoidable during this transition. Recent examples (such as those of the Eastern and Central European countries) should be brought to their attention, and a workshop focusing on simple, practical issues of market economy is badly needed.

4.2.2 Revolutions in Energy Billing

Energy billings to customers are primarily based on estimated averages over the entire population. Even in cases where meters are installed, charges to customers are still based on estimated use. Government subsidies and ownership promoted customer insensitivity to such billing practices; to make customers liable for the amount of energy they consume, the billing system will need to be overhauled. This includes the widespread installation of heat meters, and the subsequent hiring and training of meter readers. Without a rational billing system in place, it will be difficult to implement energy conservation measures.

4.3 Low-Cost Equipment Recommendations

Both the heat production and distribution segments of the IRG energy audit are covered by the following equipment recommendations.

4.3.1 BHSE Equipment Recommendations

- Flowmeters to measure mazut feed. Four meters are needed to fit pipelines with a diameter of 133 mm and two meters to fit pipelines with a diameter of 60 mm. Signals from these six flow meters would then be transmitted to the main operation and control room of TES-1. Discussion with specialists from Honeywell suggested that Honeywell Smart Magnetic Flowmeters, Magnet 3000 or similar instruments should satisfy performance requirements. A diagram showing the locations of such instrumentation appears in **Figure 6**.

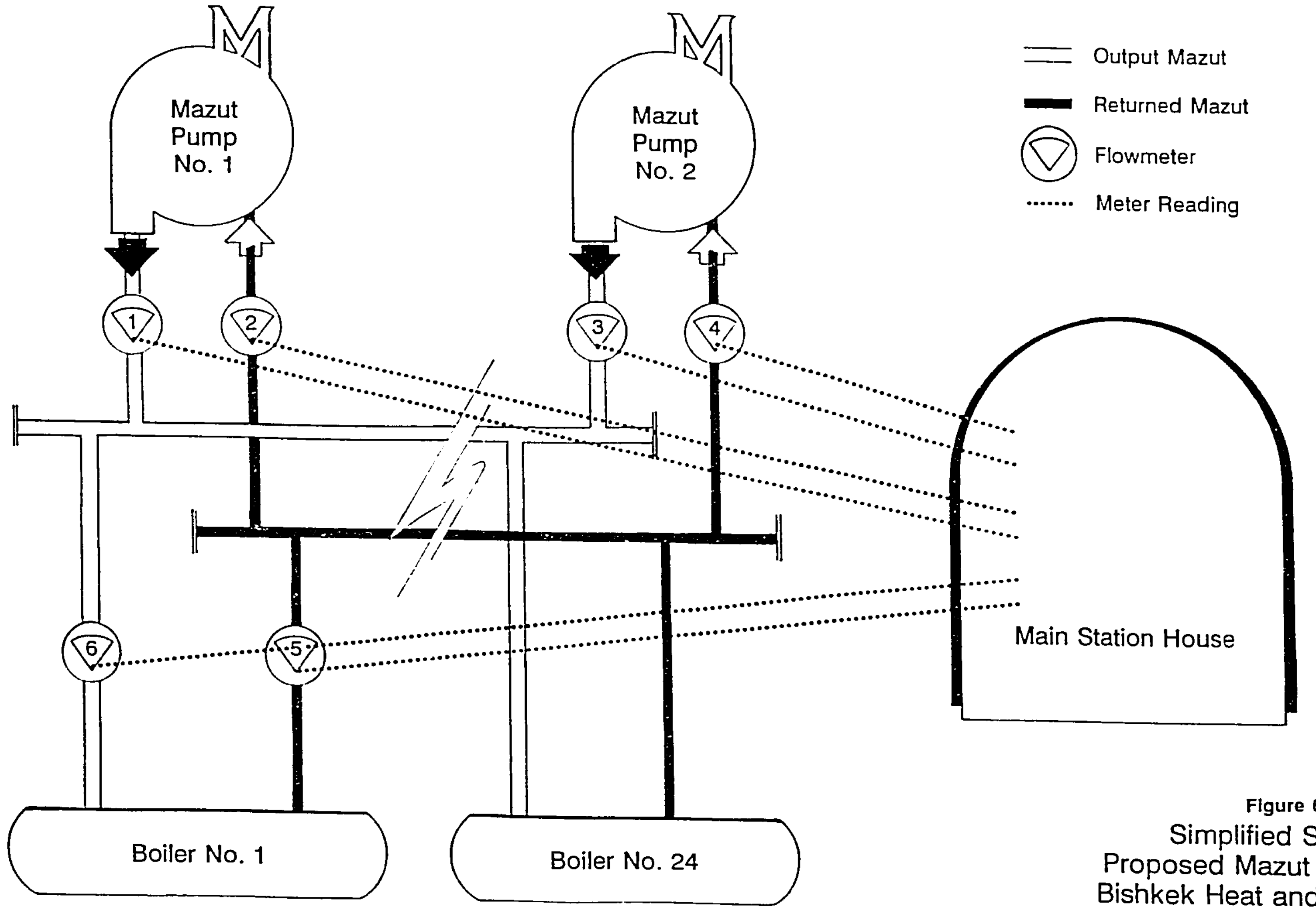


Figure 6.
Simplified Scheme
Proposed Mazut Flow Meters
Bishkek Heat and Power Plant

- Hot water flowmeters. Hot water flowmeters are recommended to monitor the flow rates of the main supply and return lines of the district heating system. Specifically, the BHSE system will need seven meters to fit pipelines with a diameter of 720 mm; two meters to fit pipelines with a diameter of 920 mm; and one meter to fit pipe diameter of 820 mm.

  Flow signals from these ten meters would also be transmitted to the main operating room of TES-1. The maximum distance from transmitters to receivers is 1,000 meters. Pitot-tube (Annubar) type flowmeters should yield measurements accurate enough for the purpose here.

- Temperature probes. These would be used to measure hot water temperatures in the BHSE network, and transmit signals to the main operating room of TES-1. Honeywell ST3000 Smart Temperature Transmitter (Type STT300-00-0-EP-DE), or similar type of temperature probe should perform the task. The high temperature range of the probe should range from 150° to 300° C.

- Pressure probes. Two pressure probes are necessary to measure the gas pressure at points before and after the natural gas supply station, transmitting the signals to the main operating room of TES-1. Honeywell ST3000 Smart Transmitter for Absolute Pressure (Model STA140-E1G-00000-MB-TC) or a similar type of pressure probe should be used.

- Air pollution monitoring systems. A system is needed to monitor air pollution at the power plant which would measure CO_2, SO_2, NO_x, and V_2O_5 (vanadium oxide) in the flue gas. Signals should be transmitted to the main operating room of the plant, with alarms for those instances in which the pollutant exceeds pre-set limits.

- Water pollution monitoring systems. Portable water analyzers indicating levels of the following chemical components should be utilized to monitor the waste water streams from the power plant.

- Oxygen analyzers for hot water system. These would include 4 stationary oxygen probes for deaerators with measurement limits of 0-100 mg/l, and 10 probes with measurement limits of 0-50 mg/l, as well as 2 portable oxygen probe (one each with the aforementioned measurement limits).

- Flammable gas detector. To provide safe working conditions on natural gas equipment, the power plant needs portable gas analyzers with the capabilities of measuring methane (CH_4), Hydrogen (H_2), and Carbon monoxide (CO) in mg/cm^3 values.

- Thermalvision for the maintenance and operation of the power plant. Portable thermalvision device with measurement limits ranging from 0° to 200° C are recommended. Equipment features should include sound alarm, color monitor screen, color printer, and/or video recorder.

- Fuel quality measurement system. A fuel quality measurement system that has the capability to measure the following:

Portable or stationary fuel quality measurement devices for coal:	moisture ash content volatile sulphur caloricity	0%-50% 0%-60% 5%-60% 0%-5% 2,000 - 7,000 Kcal/kg
for natural gas:	caloricity density	7,000 - 10,000 Kcal/m^3 0.5-1 kg/m^3
for mazut:	moisture viscosity @ 80° C density @ 20° C sulphur flash temperature	0-10 5 0-20 0.5-1.2 g/ml 0%-6% 80°-200° C

Maintenance of the purchased equipment, operation training of local personnel, stable supplies of spare parts and components, and possible local supplies of the same are important factors in the final decision on the purchase of proper equipment and instrumentation.

4.3.2 Boiler Room Equipment Recommendations

- Microcomputers for improving power plant operations. These are recommended in two options:

  Option 1. Two IBM PC/AT 386, or equivalent, microcomputers are recommended, with the following configuration: processor 33 MHz 80386FX; coprocessor 80387; 16 MB of on-board memory (or 8 MB); 200 MB hard disk drive (or 160 MB); 2 floppy disk drives, one each 5.25" (1.2MB) and 3.5" (1.44 MB); 4 serial ports RS/232 S; 1 parallel port; Super VGA color monitor; display adapter with Super VGA card (1024 kB); enhanced (101 key) keyboard; Microsoft Inport mouse; and Epson FX-1050 printer.

  Option 2. Eight IBM PC/286, or equivalent, microcomputers are recommended, with the following configuration: processor 16 MHz 80286; coprocessor 80287; 4 MB of on-board memory (or 2 MB); 80 MB hard disk drive; 2 floppy disk drives, one each 5.25" (1.2 MB) and 3.5" (1.44 MB); 3 serial ports RS/232 S; Super VGA color monitor; display adaptor with super VGA card with 512 kB; enhanced (101 key) keyboard; Microsoft Inport Mouse; and Epson FX-1050 printer.

4.3.3 IRG Equipment Recommendations

The IRG Energy Audit Team has developed the following list of low- to medium-cost recommendations, listed in order of their priority:

- Infrared and/or contact thermometers. Such simple, inexpensive devices are useful to detect defective pipeline insulation, as well as to locate severe heat/hot water leakages in underground pipelines. Since it is difficult to detect small leaks in a large pipeline network, Team members recommend the use of hand-held infrared (IR) thermometers to measure the surface temperature of the ground where pipelines are buried. These thermometers are priced between $500 and $1,000 each.

- Pitot tube-type flowmeters. These devices are easy to use and their accuracy good. Such instruments would permit readings of water flow rate, accounting for half of the information provided by heat meters. With this device, flow rates could be measured at sufficient points within the distribution system. Consequently, significant leaks in the system could be located within a brief amount of time.

  When readings are taken in sufficiently small time intervals, the total amount of hot water passage can be estimated with reasonable accuracy, providing a basic quantitative analysis for hot water consumption within a range of boundaries. If a temperature differential between the feed and return line can be estimated with some degree of accuracy, then the heat consumption rate can be computed.

- Heat meters. These are medium-priced items which, when used in conjunction with Pitot flowmeters would provide information on heat consumption rates between any supply and return hot water line. The IRG Energy Audit Team strongly recommends heat meters be installed for individual customers or groups of customers (such as those in apartment complexes), so individuals may be charged for actual consumption. Suitable meters for hot-water systems are available in the US for $800 to $1,800 each, based on the size of the heat load to be measured.

- Steam traps. Steam traps in used at industrial site at the time of audit were ineffective or non-existent. Based on the IRG Energy Audit Team's previous experiences in Eastern and Central European countries, use of the recommended steam traps provides substantial payback. A list of locations where quality steam traps are most needed was given to the team by the engineers at the Wool Fabric Plant.

- Portable gas analyzers. Hand-held oxygen and stationary CO analyzers manufactured by Bacharach are highly recommended as an inexpensive way to determine the combustion efficiency of boilers. In addition, portable gas analyzers (Enerac 2000, or Bacharach 300) are medium priced instruments which monitor oxygen, CO, CO_2, SO_2, and NO_x. They not only calculate combustion efficiency, but also monitor other air pollutants, and perform well in dust-free environments.

- Stationary oxygen analyzers. The stationary zirconium oxygen analyzer as recommended by users is the most accurate device of its kind, handling up to eight probes with one recorder and converter. Considering the amount of coal and heavy oil burned at the Bishkek Heating and Power Plant, it is advisable to optimize the air and fuel ratio of all 24 boilers. A diagram showing the proposed scheme is presented in **Figure 7**.

Assuming a 10% reduction in excess combustion air could be achieved, a fuel savings of 1% would result, representing a savings of 8,958 MT of coal, 9,775 million m^3 of natural gas, and 1,853 MT of mazut per year. Using US $20/MT of coal, US $90/MT of mazut, and US $53.90/1,000 m^3 of natural gas, the dollar value of savings would equal $179,160 in coal, $166,770 in Mazut, and $526,926 in natural gas per year.

- Basic monitoring and control system for Bishkek Power Station (TES-1). On the advice of experts from Honeywell, a basic heat flow monitoring and recording system is proposed which is capable of monitoring incoming heat streams (make up), outgoing heat streams (total heat in-flow to the loop), and return streams from the loop. A total of 18 monitoring stations would be installed to allow measurement of hot water flow rates, temperatures, and heat flow rates of all major streams. This system would be the foundation upon which other control systems could be built.

  The total cost of this package as quoted by Honeywell is US $114,490 FOB Vienna. The shipping cost from Vienna to Bishkek and any custom tariffs will be extra. Included in this quotation is all the hardware instrumentation, software, one week of installation supervision and one week of commissioning. Costs of installation, including electrical, mechanical, and civil work at the job site, and shielded cables necessary for connecting computer/instruments are included in the estimate.

- Thermal energy conservation program for an apartment building. With experts from Honeywell, a basic heat flow monitoring, recording and regulating system is proposed. This system would cover 40 to 68 individual apartments in one building, where each apartment's radiator would be thermostatically controlled. Shortcomings of this demonstration program are not directly related to the underlining technical requirements, but result from human factors. Realistic and rational billing based on energy consumption of individual apartments is a must for an energy program as such to yield unbiased results.

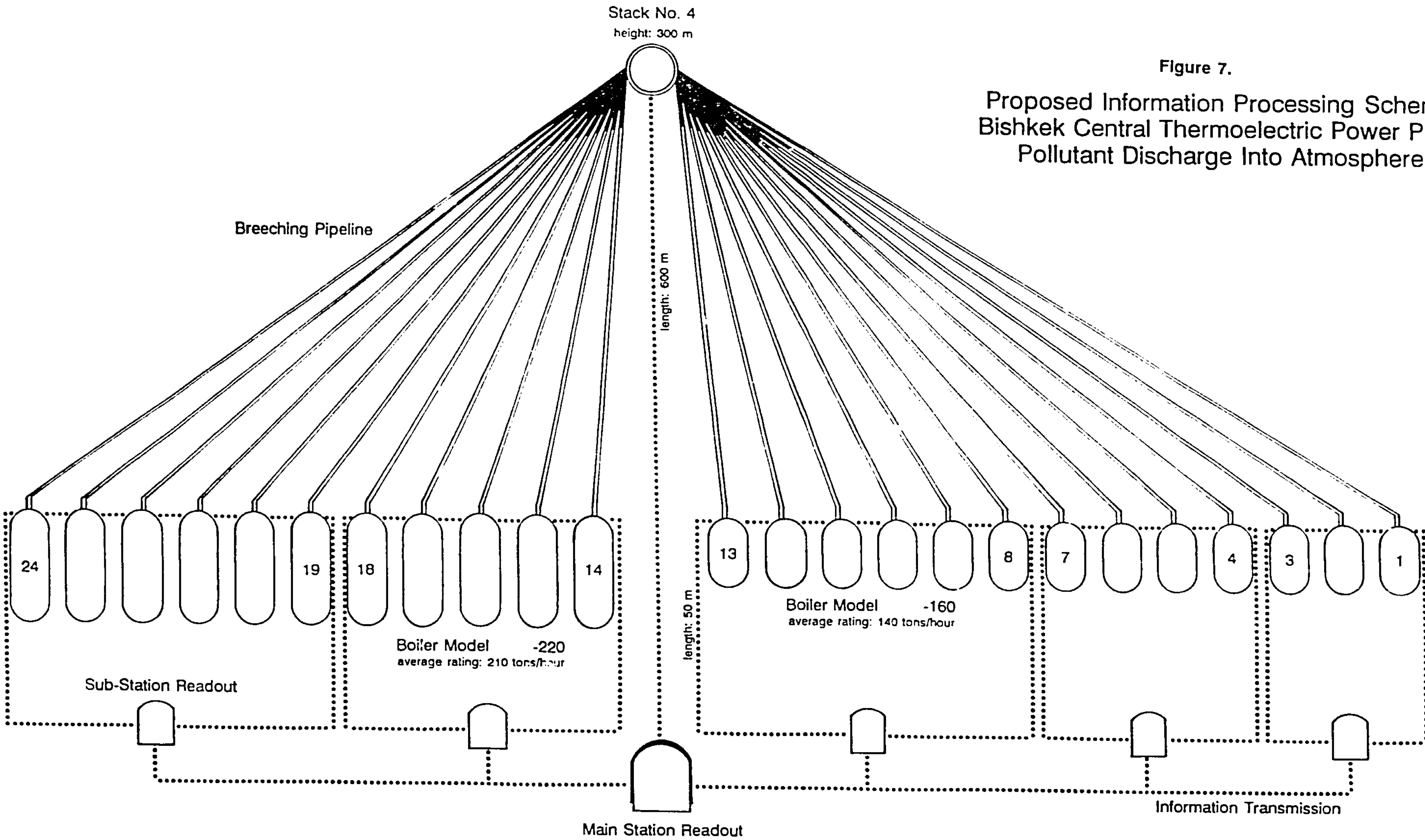
4.4 Medium/Long-range Projects

4.4.1 Original Plans for the Construction of TES-2

In 1984, an expansion plan was approved to build the second cogeneration plant, known as TES-2, in Bishkek. The plan called for constructing steam boilers to produce hot water for the district heating plant, thus satisfying the growth in heating demand. It was decided that seven boilers with a capacity of 160 MT/hour each and fired by natural gas (with some mazut) would be able to produce steam at a pressure of 10 atm and temperature of 540° C. It was also decided that there would be two steam turbines of 160 MW each to produce electricity.

Figure 7.

Proposed Information Processing Scheme
Bishkek Central Thermoelectric Power Plant
Pollutant Discharge Into Atmosphere



This plan was initiated when the Soviet authority was still in place; as such, it is now delayed due to the constraints of economic and political transition. While the original completion date was 1995, the new date of completion is tentatively set for the year 2000.

4.4.2 Current and Future Directions for TES-2

At the time of audit, it has not yet been determined if the republic had the necessary funding to finish this project as planned in 1984, and there was the question of whether the original design best satisfies existing criteria. The government's position is that it will be difficult to fund this project without help from Western nations, and obviously, aid from these countries depends upon, among other things, the energy pricing and utilization efficiency meeting world standards. Without sufficient energy management and subsequently proven results, it would be difficult to attract any foreign investment.

According to preliminary investigation by the IRG Energy Audit Team, a gas turbine combined cycle with steam injection, or Chen cycle, would increase the efficiency of energy resource utilization substantially more than the original design of steam to hot water only. The electric power efficiency of a gas turbine combined cycle can be as high as 60%.

4.5 Replication Potential

4.5.1 At the system level

Thermal Power Plant: Heat Production

Combustion gas analyzers can be applied to all other boiler stations, and portable gas analyzers can be extensively utilized within the small (600) boiler rooms which exist throughout the city.

The basic measuring and monitoring system proposed for the boiler room and heating plant should eventually become part of a microcomputer control system which includes automatic regulation of individual boilers. Such systems can be extended to cover all district boiler houses within the republic.

Distribution Systems

Pressure, temperature, flow and heat meters suggested above are clearly needed throughout the distribution systems. Individual customers - commercial, industrial, and residential - need them as well as a basis for the new billing process. These are essential to trace water leaks, regulate pressure balance, monitor the heat balance, and to evaluate the performance of each section of the network.

Contact and infrared thermometers are good tools for tracing heat leaks in pipeline insulation and hot water leaks of above- and underground pipelines throughout the network. They are also useful to detect potential bearing failure of water pumps in the booster pump stations.

Pitot tube flow meters and pressure gauges at strategic locations are necessary to monitor the general performance of the local sections, and are also useful in tracing the source of water hammer effect and help eliminate such problems.

End User/Customer Systems

In general, steam traps have an excellent payback for industrial customers, heat meters with varying degrees of sophistication would be useful for all customers within the network, and the monitoring and control system designed for apartment buildings can be applied to commercial and industrial sites as well.

4.5.2 At the National Level

Heat Production

Such instruments and control systems should be applicable to other municipal district heating systems within the republic.

Distribution

All recommendations made here for BHSE should be applicable to other open distribution systems within the republic.

End User (Customer) Systems

Recommendations made here for the customers of BHSE should be applicable to other district heating systems within the republic.

Appendix I

IRG Energy Questionnaire

INTERNATIONAL RESOURCES GROUP

DISTRICT HEATING QUESTIONNAIRE

A. IDENTIFICATION

1. PLANT'S NAME ______________________________ PHONE NUMBER
2. ADDRESS ______________________________ __________
3. NAME OF CONTACT, AND POSITION ______________________________

PHONE NO ______________ FAX NO ____________ TELEX ____________

4. CUSTOMERS AND TERRITORY IT SERVES:

INDUSTRIAL: No OF CUSTOMERS ______; SIZE ________ Kg OF STEAM/HR
AVG ______; MAX ______; MIN ______; ________ M OF H2O/HR
COMMERCIAL: No OF CUSTOMERS ______; SIZE ________ Kg STEAM/HR
AVG ______; MAX ______; MIN ______; ________ M H2O/HR
RESIDENTIAL: No OF CUSTOMER ______; SIZE ________ Kg STEAM/HR
AVG ______; MAX ______; MIN ______; ________ M H2O/HR

B. MODE OF OPERATION

5. DATE OF PLANT COMMISSIONING
6. NUMBER OF EMPLOYEES; TOTAL; PER SHIFT
7. HOW MANY HOURS/DAY DOES THE PLANT OPERATE (AVERAGE)

   HOW MANY DAYS PER YEAR
8. WHEN IS THE PLANT SHUT DOWN FOR MAINTENANCE, AND FOR HOW LONG
9. IS THE PLANT OPERATION YEAR AROUND ?
   IF NO, WHEN IT IS ON AND WHEN IT IS OFF;

C. HEAT EXCHANGE STATIONS

10. ATTACH A DIAGRAM SHOWING THE TERRITORY THE HEATING PLANT IS SERVING
11. HOW MANY STEAM TO HOT WATER EXCHANGER STATIONS ARE THERE IN THE SYSTEM ?
12. WHAT IS THE TOTAL LENGTH OF STEAM LINE ? ARE THERE PRIMARY AND SECONDARY STEAM LINES IN THE SYSTEM ?
13. WHAT IS THE TOTAL LENGTH OF THE HOT WATER LINES IN THE SYSTEM ?

55

14. LIST OF ALL LINE SIZES AND THEIR RESPECTIVE LENGTHS.

PIPE DIAMETER	LENGTH IN KM
____________________	____________________
____________________	____________________

15. HOW MANY KCAL, BTU, OR GJ OF HEAT PER HOUR DELIVERED BY THE SYSTEM ?

MAXIMUM	MINIMUM	AVERAGE
______________	______________	______________
______________	______________	______________

16. WHAT IS THE WATER CIRCULATION RATE OF THE SYSTEM ?

MAXIMUM	MINIMUM	AVERAGE
______________	______________	______________
______________	______________	______________
______________	______________	______________

17. HOW MANY HOT WATER PUMPS USED IN THE SYSTEM ? WHAT ARE THEIR SIZES ?

HORSE POWER FOR THE MOTORS ________________________
FLOW RATE FOR THE PUMPS ___________________________

18. ARE THE PUMPS EQUIPPED WITH CONSTANT SPEED OR VARIABLE SPEED MOTORS ?

19. ARE THERE SPARE PUMPS AVAILABLE FOR ROTATIONAL MAINTENANCE ?

20. ELECTRIC POWERED PUMP OR DIESEL POWERED PUMP ? IS THERE EMERGENCY POWER AVAILABLE IN CASE OF A BLACKOUT ?

21. WHAT ARE THE HOT WATER PIPELINE MADE OF ? STEEL, COPPER, IRON ETC.

22. HOW OLD ARE THE HOT WATER LINES ? OLDEST ____ YRS. NEW ONE ____ YRS

23. WHAT IS THE PRESSURE OF THE HOT WATER LINE ON THE DELIVERING END ?

24. WHAT IS THE PRESSURE AT THE RETURN END ?

25. WHAT IS THE TEMPERATURE OF THE HOT WATER AT THE DELIVERING END ?
WINTER ______________ SUMMER ________________

26. WHAT IS THE TEMPERATURE OF THE HOT WATER AT THE RETURN END ?
WINTER ______________ SUMMER ________________

27. ARE THERE BOOSTER PUMPS ALONG THE ROUTE TO MAKE UP FOR THE PRESSURE LOSS ?

28. WHAT IS THE WATER LOSS OF THE ENTIRE SYSTEM ? WINTER _______
SUMMER ________

56

D. ENERGY SUPPLIES AND DEMANDS

29. LIST ALL ENERGY PRODUCTS USED IN THE PLANT, E.G.
NATURAL GAS, LOW Btu GAS, COAL, LIGNITE, COKE, CHARCOAL, WOOD, FUEL OIL, DIESEL OIL, BAGASSE, AGRICULTURAL WASTE, ELECTRICITY, STEAM, HOT WATER, ETC

30. HOW ARE THEY BROUGHT TO THE PLANT ?
PIPE LINE, TRUCK, TANK CAR, RAIL CAR, BARGE, HIGH VOLTAGE LINE, ETC

31. IS THERE EXTRA MARGIN OF SUPPLY OF SUCH FUELS IF THE PLANT CHOOSES TO GO COGENERATION ?
IF YES, HOW MUCH ?
IF GAS, HOW MUCH, AND UNDER WHAT PRESSURE ?

32. LIST THE RELEVANT SPECIFICATIONS FOR EACH FUEL/ENERGY PRODUCT

HEATING VALUE (HV & LV) KCAL/KG (SOLID OR LIQUID)
KCAL/CU. M (GAS)
STEAM PRESSURE, TEMPERATURE, AND RATE (KG/HR)
GAS PRESSURE, FLOW RATE
ELECTRICITY VOLTAGE, AND LINE (TRANSFORMER) CAPACITY
HOT WATER PRESSURE, TEMPERATURE, AND RATE (KG/HR)

33. IN CASE OF STEAM OR HOT WATER, WHAT IS THEIR SOURCE, BOILER, TURBINE ?

34. WHAT IS THE CURRENT PRICE OF EACH ?

RB /CU. METER OF GAS
RB /METRIC TON OF COAL, COKE, LIGNITE, ETC
RB /METRIC TON OF FUEL OIL
RB /kWh OF ELECTRICITY FRM THE GRID
RB /METRIC TON OF STEAM, OR HOT WATER

35. WHAT IS THE TARIFF OF ELECTRICITY CONSUMED AT THE PLANT ?

DEMAND CHARGE

CONTRACT DEMAND CHARGE	RB	/kW
MAX DEMAND CHARGE	RB	/kW
OVER CONTRACT PENALTY	RB	/kW

DEMAND CONSTRAINTS

36. DO THEY EXPERIENCE POWER INTERRUPTIONS OR SHORTAGE ?

ROTATIONAL BLACK OUT
BROWN OUT

91

37. FOR THE MOST RECENT 12 MONTHS, PLEASE FILL OUT THE TABLE BELOW:

Month	Year	HOT WATER Gener (GJ) x1,000	HOT WATER Demand (GJ)	HOT WATER Cost prod (RB) x1,000	NATURAL GAS Usage (MCM)	NATURAL GAS Cost (RB) x1,000	FUEL OIL Usage (MT)	FUEL OIL Cost (RB) x1,000
Jan								
Feb								
Mar								
Apr								
May								
Jun								
Jul								
Aug								
Sep								
Oct								
Nov								
Dec								
Total								

38. ARE THERE DATA AVAILABLE ON DAILY AND SEASONAL VARIATIONS IN HOT WATER LOAD ?

39. IS THERE A DAILY HOT WATER HEATING LOAD CURVE AVAILABLE ?

40. IS COGENERATION AVAILABLE AT THE SITE ?

IF YES, HOW MUCH ELECTRICITY IS GENERATED BY THE PLANT LAST YEAR ?

FUEL USED FOR COGENERATION, QUANTITY, AND HEAT CONTENT (H)

IS THE STEAM CONSUMED WITHIN THE PLANT AND HOW MUCH ?

E. BOILER INFORMATION

41. PROVIDE DATA FOR EACH BOILER

MAKER

TYPE/MODEL

CAPACITY

DATE INSTALLED

HOW MANY TIMES OF MAJOR WORKS DONE, AND ON WHAT BOILERS ?

STEAM PRESSURE

TEMPERATURE

FUEL CONSUMPTION

FUEL USED

WHAT ARE THE ALTERNATIVE FUELS ?

SOURCE OF FEED WATER

WATER TREATMENT USED

WATER QUALITY AFTER TREATMENT

MAKE UP WATER

PERCENTAGE OF CONDENSATE RETURN

PEAK DEMAND FOR STEAM

F. TURBINE INFORMATION

42. PROVIDE DATA FOR EACH TURBINE

MAKER

TYPE/MODEL

CONDENSING
BACK PRESSURE
EXTRACTION

RATING CAPACITY

DATE INSTALLED

STEAM PESSURE
INLET
OUTLET

STEAM TEMPERATURE
INLET
OUTLET

BY PASS

VALVES

MAJOR REPAIR WORKS DONE

G. <u>MEASUREMENT AND METERING</u>

43. HOW IS HOT WATER SUB-METERED FOR RESIDENTIAL END USERS ?

HOW IS HOT WATER SUB-METERED FOR COMMERCIAL END USERS ?

HOW IS STEAM/HOT WATER SUB-METERED FOR INDUSTRIAL END USERS ?

44. WHAT IS THE PERCENTAGE OF TOTAL ELECTRICITY USED IN OFIICES ?

G. <u>COGENERATION FACILITY</u>

45. WHAT ARE THE REQUIREMENTS FOR CONNECTION TO THE GRIDS ?

46. WHAT IS THE ELECTRIC RATE IF DISTRICT HEATING PLANT INTENDS TO SELL ITS COGENERATION POWER TO THE GRID ?

RB. /kW DEMAND
RB. /kWh USAGE

47. WHAT IS THE BACK-UP POWER COST CHARGED BY THE GRIDS ?

RB. /kW DEMAND

48. HAS THE PLANT EVER BEEN CONSIDERING TO DO COGENERATION THEMSELVES ?

IF YES, WHAT HAPPENS NEXT ?

IF YES, WHY THERE IS NO COGENERATION ON SITE ?

IF NOT, WHY NOT ?

49. IS THE ELECTRIC UTILITY CO. WILLING TO BE A PARTNER OF THIS COGENERATION VENTURE ?

IF NOT, WHY NOT ?

IF YES, WHAT % THEY WOULD LIKE TO PARTICIPATE ?

50. DOES THE HOST SITE (PLANT) WANT TO BE A PARTNER IN THIS JOINT VENTURE?

IF NOT, WHY NOT ?

IF YES, WHAT % THEY WOULD LIKE TO PARTICIPATE ?

51. ARE THERE OTHER PARTIES WHO WOULD LIKE TO CONSIDER TO BE A JOINT VENTURE PARTNER ?

52. IS THE DISTRICT HEATING PLANT ALSO IN CHARGE OF DISTRIBUTING THE HOT WATER TO CUSTOMERS ?

53. ARE THERE TWO SEPARATE AUTHORITIES: ONE TAKES CARE OF THE BOILER SIDE, AND THE OTHER TAKES CARE OF DISTRIBUTING THE HEAT ?

54. WHAT IS MANAGEMENT'S PREDICTION THE GROWTH OF HEATING DEMAND IN THE NEXT TEN YEARS ?

55. ARE THERE ANY ENERGY MANAGEMENT OR ENERGY CONSERVATION PROGRAMS IMPLEMENTED IN THE LAST THREE YEARS ? IF YES, WHAT ARE THEY ?

56. OTHER COMMENTS OR INFORMATION THAT ARE PERTINENT TO THE ENERGY AUDIT OF THIS DISTRICT HEATING PLANT ?

57. WHAT ARE THE CRITICAL AREAS WHERE LOW COST INSTRUMENTS CAN MAKE A SIGNIFICANT CONTRIBUTION TOWARD EFFICIENCY IMPROVEMENT OF THE SYSTEM.

58. PLEASE ATTACH AN ORGANIZATION CHART SHOWING THE MAJOR FUNCTIONS:

   * ADMINISTRATION
   * OPERATIONS
   * MAINTENANCE
   * ENGINEERING
   * ACCOUNTING
   * CUSTOMER SERVICE
   * ETC

59. PLEASE INDICATE THE TOTAL NUMBER OF PERSONS AND THE NUMBER OF SUPERVISORS IN EACH FUNCTIONS.

60. ARE ANY MAINTENANCE AND/OR REPAIR FUNCTIONS CONTRACTED TO OUTSIDE COMPANIES ? PLEASE DESCRIBE THE ARRANGEMENT.

61. HOW MANY POWER STATIONS SUPPLY THERMAL ENERGY TO THE DISTRICT HEATING SYSTEM ? PLEASE DESCRIBE EACH ONE BRIEFLY.

62. HOW IS THE PRICE FOR THERMAL ENERGY ESTABLISHED ? HOW OFTEN CAN IT BE ADJUSTED ? WHO HAS THE AUTHORITY TO APPROVE A PRICE ADJUSTMENT ?

6

63. PLEASE DESCRIBE THE TYPES OF CUSTOMERS WHO RECEIVE SERVICE FROM THE DISTRICT HEATING SYSTEM ?

* PRIVATE RESIDENTIAL % ________
* COLLECTIVE RESIDENTIAL % ________
* LIGHT INDUSTRY % ________
* HEAVY INDUSTRY % ________
* GOVERNMENTAL AGENCIES % ________
* COMMERCIAL % ________
* OTHER % ________

64. WHAT ARE THE RATES FOR EACH GROUP OF THE ABOVE CUSTOMERS ?

65. HOW ARE THE RATES DERIVED ? ARE THERE COST ACCOUNTINGS PRACTICED ? IF YES, PLEASE DESCRIBE BRIEFLY.

66. ARE EACH CUSTOMER'S USAGE METERED, AND CHARGED ACCORDING TO HOW MUCH THEY EACH CONSUME ?

67. ARE ANY CUSTOMERS TO WHOM STEAM OR HOT WATER IS DIRECTLY SUPPLIED BY THE POWER PLANTS, WITHOUT INVOLVEMENT FROM THE DISTRICT HEATING SYSTEM ? IF SO, WHAT ARE THE QUANTITIES SUPPLIED, AND WHAT ARE THE PRICE CHARGED ?

68. WHO IS RESPONSIBLE FOR OPERATION AND MAINTENANCE OF THE PRIMARY PUMPS FEEDING THE SYSTEM ?

69. WHO AND WHAT DEPARTMENT IS RESPONSIBLE FOR DEVELOPING AND DIRECTING ENERGY MANAGEMENT AND CONSERVATION PROGRAMS ?

70. WHAT HAS BEEN THE RESULT OF THESE PROGRAMS DURING THE PAST YEAR ?

71. WHAT ARE THE MOST IMPORTANT CAUSES OF HEAT LOSS IN THE SYSTEM ?

* WATER LEAKAGE
* STEAM LEAKAGE
* LACK OF SUB-METERING
* PIPING LAYOUT AND SIZES
* POOR INSULATION
* PUMP INEFFICIENCY
* LACK OF TEMPERATURE REGULATOR FOR INDIVIDUAL CUSTOMERS
* OTHERS (PLEASE SPECIFY)

72. PLEASE ESTIMATE THE AMOUNT OF EACH OF THE ABOVE LOSSES AS A PERCENT (%) OF TOTAL THERMAL ENERGY DELIVERED TO THE SYSTEM.

73. WHAT CREATES SUCH HEAT LOSSES ?

* LACK OF MAINTENANCE
* LACK OF PERSONNEL
* LACK OF ACCURATE INSTRUMENTS
* LACK OF SPARE PARTS
* LACK OF INCENTIVE
* POOR DESIGN
* PIPE NETWORK TOO OLD
* PUMPING EQUIPMENT TOO OLD
* OTHER (PLEASE SPECIFY)

74. WHO MANAGES THE WATER TREATMENT AND WATER QUALITY FOR THE SYSTEM ?

75. PLEASE DESCRIBE THE COSTS OF OPERATING THE DISTRICT HEATING SYSTEM. PLEASE PROVIDE COSTS AS RUBLES PER KCAL FOR A TYPICAL MONTH DURING THE HIGH DEMAND SEASON AND DURING THE LOW DEMAND SEASON:

	HIGH DEMAND RB/KCAL	LOW DEMAND RB/KCAL
* WATER DEMAND CM/HR		
* FUEL COST		
* WATER COST		
* MAINTENANCE COST		
* LABOR		
* MATERIAL		
* OPERATING COST		
* ELECTRICITY COST		
* DEPRECIATION		
* TAXES AND INSURANCES		
* ADMINISTRATIVE OVERHEAD		
* SUPPLIES		
* OTHERS (PLEASE SPECIFY)		

76. WHAT ENERGY-SAVING PROJECTS HAVE BEEN IDENTIFIED THAT MAY REQUIRE CAPITAL EXPENDITURES:

A. PROJECTS THAT WOULD REQUIRE LESS THAN U.S. $10,000. EACH.

B. PROJECTS THAT WOULD REQUIRE MORE THAN U.S. 10,000. EACH.

77. PLEASE ESTIMATE THE ANNUAL BENEFITS THAT WOULD BE ACHIEVED BY EACH ABOVE PROJECTS.

78. ARE COMPUTERS USED IN THE SYSTEM ?

* FOR PROCESS CONTROL
* FOR DATA COLLECTION
* FOR PROCESS MONITORING
* FOR BILLING AND BOOK KEEPING
* FOR OFFICE AND COST ACCOUNTING

79. PLEASE DESCRIBE BRIEFLY THE TYPE OF COMPUTER EQUIPMENT USED AND THE FUNCTIONS PERFORMED.

80. DO WORKERS, AND MANAGERS RECEIVE TRAINING IN ENERGY SAVING AND COST SAVING ? IF YES, WHAT ARE THE TRAINING PROGRAMS, AND WHO DOES THE TRAINING ?

81. DO WORKERS AND MANAGERS RECEIVE BONUSES OR OTHER FINANCIAL RECOGNITION FOR ENERGY SAVING AND COST SAVING IDEAS ? IF SO, HOW MUCH AND HOW OFTEN ?

82. WHAT IS THE WATER PRESSURE

* AT THE OUTLET OF THE PUMPS FEEDING THE SYSTEM ?
* AT THE FURTHEST POINT IN THE SYSTEM ?
* AT THE POINT OF RETURN TO INLET OF PUMPS ?

83. IS WATER TEMPERATURE AND PRESSURE MEASURED AT INTERMEDIATE POINTS IN THE SYSTEM ?

84. IS WATER FLOW RATE MONITORED AT INTERMEDIATE POINTS IN THE SYSTEM ?

85. HOW ARE MAJOR LEAKS DETECTED ?

86. WHAT IS THE HOT WATER LOSS FOR THE ENTIRE DISTRICT HEATING SYSTEM,

* HIGH DEMAND SEASON
* LOW DEMAND SEASON

87. WHAT IS THE FURTHEST POINT FROM THE MAIN PUMPING STATION IN KM ?

88. WHAT IS THE ESTIMATED RESIDENCE TIME FOR WATER IN THE SYSTEM,

* AT PEAK LOAD
* AT OFF PEAK LOAD