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ENERGY EFFICIENCY AUDIT REPORT

BIOTIKA PHARMACEUTICAL
Prague, Czechoslovakia

JANUARY 1992

PREPARED BY: RESOURCE MANAGEMENT ASSOCIATES OF MADISON, INC.
Madison, WI

and

ELEKTROPROJEKT
Banska Bystrica, Czechoslovakia

U.S. EMERGENCY ENERGY PROGRAM FOR EASTERN AND CENTRAL EUROPE

U.S. AGENCY FOR INTERNATIONAL DEVELOPMENT
BUREAU FOR EUROPE
WASHINGTON, D.C. 20523

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U.S. EMERGENCY ENERGY PROGRAM FOR EASTERN AND CENTRAL EUROPE

U.S. AGENCY FOR INTERNATIONAL DEVELOPMENT
BUREAU FOR EUROPE
OFFICE OF DEVELOPMENT RESOURCES
ENERGY & INFRASTRUCTURE DIVISION
WASHINGTON, D.C. 20523

USAID Contract EUR-0015-C-1006-00

Table of Contents

i. Executive Summary 1

1.0 Description of Energy Efficiency Program 3

2.0 Plant Description 4

3.0 Plant Energy Profile 5

4.0 Audit Description 14

5.0 Summary of Results 16
5.1 ECO's Recommended for Demonstration 16

6.0 Plant Energy Management/Organization 20

7.0 Implementation Assessment 21
7.1 Status of Equipment 21
7.2 Status of the Demonstration Project 22
7.3 Preparation for the Seminar 22
7.4 Status of Energy Conservation Measures 22

List of Tables

Table 1. Annual Energy Use (1990) 6

List of Figures

Figure 1. Annual Energy Use 7
Figure 2. Electrical Consumption 8
Figure 3. Electrical Demand 9
Figure 4. Energy Use Distribution 11
Figure 5. Energy Cost Distribution 12
Figure 6. Energy Use By Product 13

List of Appendices

Appendix A
Specification for Programmable Computer Control System

Appendix B
Specification for Purchase of Test Equipment

Appendix C
Acquisition of Technical Literature

Appendix D
Photographs

Appendix E
List of Abbreviations

i. Executive Summary

Czechoslovakia faces unprecedented energy problems including uncertain oil supplies, pollution from coal, and questions about the future of nuclear energy. The Czechoslovakian industrial sector has experienced large increases in energy prices, the latest in January, 1991, bringing energy costs in-line with world energy prices. At the same time, the country is embarked upon a fundamental economic structural reform. The U.S. Agency for International Development established the Industrial Energy Efficiency Improvement Program to help mitigate the impacts of increased energy costs on the industrial sector by providing technical support through energy audits and economic support through purchase and installation of energy conservation equipment in selected representative industrial plants. Resource Management Associates of Madison, Inc. (RMA) is the technical assistance contractor for this portion of the program in Czechoslovakia. RMA was provided valuable assistance by two in-country subcontractors: 1) Stedisko pro Efektivni Vyuzivni Energie (SEVEn), in plant selection and in-country logistics; and 2) Elektroprojekt in the audit and equipment installation work.

Energy Audit

Biotika Pharmaceutical produces raw penicillin, tetra-chloro-cycline and amino acid cultures for further processing and packaging at another company plant in nearby Martin, CSFR. The plant personnel have a very good grasp of energy use and economics. Since October 1990, the plant has instituted a low-cost/no-cost energy conservation program and has reduced energy consumption per ton of product by 15% to 20%. Measures have mainly included an intensive campaign of steam trap maintenance and leak repair. There have also been electrical conservation measures instituted on large motor drives such as two speed motors for fermentation tanks, gear drives replacing V-belts, and others. Biotika has recently completed a repiping of the cooling water system to reduce the use of river water for cooling by cascading the use in the various processes. The plant has an extensive network of metering steam, water, and electricity use so that energy use for each batch of product can be closely measured.

Even with the excellent energy management program, there are potential areas for improvement. For example, steam traps are generally regarded as working if they are not blocked; concern was not so great if the trap was leaking steam through to the condensate line. A somewhat lax attitude was taken toward space heating since the heat supply is from recovered condensate heat and back pressure steam. Since the steam turbine driven air compressors required more steam than is needed by the processes, the space heat was regarded as a convenient heat sink. No control of space heat, furnished at point of use by ceiling radiant panels, was possible in the building. Consequently, room temperature control in mild weather is by the "open window method". There is also a general lack of modern test equipment. Computer monitoring systems for the energy systems and process control have been budgeted for but not yet approved.

In general, the audit team felt the Biotika plant had an energy program that could well be the envy of many U.S. plants. The major suggestion is that the energy awareness exhibited by the senior management and enforced through the energy division be expanded and communicated to the lower levels. The plant needs modern test equipment to further it's energy reduction goals by identifying and quantifying opportunities.

Based on the audit results, specifications were prepared for the demonstration of two energy conservation measures: 1) installation of thermostatic control valves and a computerized monitoring system for the radiant heating system in the Administration Building; and 2) supplying test equipment. Recommendations for technical literature are also included in this report.

The ECO's (energy conservation opportunity) recommended in this report will result in savings of over 100,000 GJ or 11.3 million Kcs ($619,000). Estimated cost of the recommended ECO's is only $22,000, resulting in a less than a one month payback.

Implementation Phase

A follow-up visit was made to Biotika on July 31, 1991. The objectives of the visit were to determine the status of installation of the energy efficiency equipment, and to assist in the preparation of a case study for the industrial efficiency seminar. The computer-controlled space heating system was completely installed and training was provided to plant staff by the equipment vendor. Training was provided by the audit team in the use of test instrumentation provided by the project.

1.0 Description of Energy Efficiency Program

Czechoslovakia's industrial sector is well developed and contains many large and heavy industries. However, there are many medium size industries within the country that consume a large percentage of the industrial energy used. Many of these industries are made up of multiple companies and plants within the country, making them ideal targets for industrial energy audit work because of high potential replication. Many of these medium-size plants are quite viable, but have not yet implemented energy conservation activities.

Increases in energy prices to equivalent world prices have put additional pressures on industrial firms to conserve energy. Changes within the economic system (increasing energy prices, privatization, etc.) will necessitate increased energy efficiency and reduced energy intensity of production. The Industrial Energy Efficiency Program will train Czech managers and engineers in energy efficiency measures and practices, as well as in energy management. This training will demonstrate the benefits of energy conservation and illustrate the advantages of making all employees aware of energy waste.

The Industrial Energy Efficiency Program is based on four distinct tasks:

1. Industrial plant screening
2. Industrial plant energy audit
3. Policy analysis
4. Implementation.

Fifteen industrial plants were screened and eight were selected to be audited. Criteria used in this selection included:

- opportunity for energy savings (with a focus on oil savings)
- potential replicability of energy saving options in similar plants or systems
- future viability of the plant in the changing economy
- size of the plant
- other activities such as joint ventures or other bi-lateral aid projects.

The energy audit activity, described in detail in this report, determined the overall energy efficiency of the plant, which was used to identify no/low cost equipment opportunities with short term payback. An assessment was made of the technical and management capabilities and capital investment decision-making processes regarding energy conservation applications. Preparation of equipment specifications and other documents required for procurement of U.S. equipment or materials completed the audit.

In the implementation phase, equipment specified in the energy audit was procured, cleared through customs, and delivered to the plant. Also, requirements for installation of the material were identified. Where possible, this was done by plant personnel, or alternatively, by CSFR contractors. Following installation, the effectiveness of the energy conservation application was evaluated.

2.0 Plant Description

Following are the key data for the Biotika Pharmaceutical Plant.

Name: Biotika Pharmaceutical

Address: 97613 Slovenska Lupca

Primary Contact: Mr. Zdeno Kadlcik, Director of Technology and Investment

Phone: 088/533

Telex: 070220

Product: Pharmaceutical, including raw penicillin, tetra-chloro-cycline and amino acid cultures

Plant size: 2,000 employees

Date of Plant Commissioning: 1954

Electric Energy:

Demand 9.3 MW
consumption 58,800 MWh
Self generation capacity 5,000 kW

Steam Requirements:

Method of supply: self generated/boilers
Average demand: 60 metric ton/hr
Temperature 445 °C
Pressure 3.8 MPa

If self produced:

Heavy oil consumption 35,624 metric ton/yr
Black Coal 20,002 metric ton/yr (4,500 kcal/kg)
Light oil 41,000 liter/yr
Natural Gas 763,764 m^3
(used in 1990 only for drying; will use as boiler fuel soon.)

3.0 Plant Energy Profile

The Biotika plant generates steam at 3.8 MPa (567 psig), 445 °C (833 °F) in three 24 metric ton/hr combined coal-oil fired boilers and two oil fired 40 metric ton/hr boilers. The three coal boilers have been modified with over fire oil burners and burn about 60% oil. This was necessary to maintain boiler capacity with lower quality coal (18,810 kJ/kg versus the design coal of 29,260 kJ/kg). One of the oil fired boilers is currently being rebuilt and will fire either natural gas or heavy oil. After this boiler is back on line, the second oil fired boiler will also be modified. The minimum steam demand in the summer is about 62 metric ton/hr, maximum is 98 metric ton/hr in winter. Annual energy use is shown in *Table 1* and *Figure 1*.

Fuel sources are "heavy oil", approximately equivalent to U.S. No. 6, and "black" coal. Although coal was originally of high quality (29,260 kJ/Kg or 12,600 BTU/lb) the present coal has a heat content of only 18,810 kJ/Kg (8,100 BTU/lb). Ash and sulphur content is very high. In order to achieve design capacities, the three coal boilers were modified with over fire oil burners and now use approximately 60% oil firing. After completion of the reconstruction of the number 5 boiler, a large part of the oil use will convert to natural gas, which is already in use in the plant for product drying. *Figure 1* illustrates the relative energy content of the three present energy sources, electricity, natural gas, coal, and oil. (This is based on 1990 use, hence natural gas use is for the last 6 months only.)

Steam pressure is reduced to 0.8 MPa (116 psig) through two back pressure steam turbines driving centrifugal air compressors and two 2.5 MW extraction turbine generators. When one of the air compressors is off line, some steam is reduced in pressure through pressure reduction valves (PRV's). They prefer to use the turbines to produce compressed air rather than the electric compressors, since the incremental energy cost is less than half that of purchased electricity. In the summer, however, the combined steam flow of the compressor steam turbines and the generator turbine is greater than can be used. Consequently, one compressor turbine is shut down in the summer and electric compressors are used. The effect of this is evident in the electrical demand and consumption (*Figures 2, Figure 3* and *Table 1*). In general, when both turbine driven air compressors are in operation, one is throttled to maintain compressed air pressure. Steam pressure is then regulated by the amount of steam extracted from the generator turbine (about 14 metric ton/hr) and, if necessary, by steam through the pressure reduction valves. When one compressor turbine is shut down, air pressure regulation is by the electric compressor, and steam pressure regulation is by the extraction steam and by the PRV's. Formerly there was a higher intermediate pressure (1.5 MPa - 220 psig) steam supplied to product dryers through a PRV, but this steam requirement has been replaced by gas-fired dryers.

Table 1. Annual Energy Use (1990)

	ELECTRICITY				BOILER FUELS		DRYER
	CONSUMPTION MWH		DEMAND KW		METRIC TONS		NM3
MONTH	GENERATE	PURCHASE	PURCHASE	GENERATE	COAL	OIL	NAT. GAS
JAN	964	3,833	5,160	2,400	1,807	3,984	
FEB	475	3,619	5,360	2,200	1,578	3,302	
MAR	606	4,064	5,200	2,700	2,543	3,268	
APR	873	3,734	5,160	2,300	2,772	2,806	
MAY	718	5,153	7,120	2,000	1,698	2,755	
JUN	844	4,890	7,160	1,800	1,350	3,019	
JUL	654	4,651	7,320	1,900	1,161	2,819	
AUG	339	2,896	7,080	2,200	665	1,483	80,328
SEP	1,116	4,859	7,120	2,300	1,338	3,000	179,761
OCT	1,058	5,123	7,200	2,100	1,964	2,927	188,461
NOV	1,099	3,452	5,280	2,200	1,426	3,261	186,272
DEC	568	3,302	5,400	2,200	1,700	3,000	128,852
TOTAL	9,314	49,576	74,560	26,300	20,002	35,624	763,674

Figure 1. Annual Energy Use

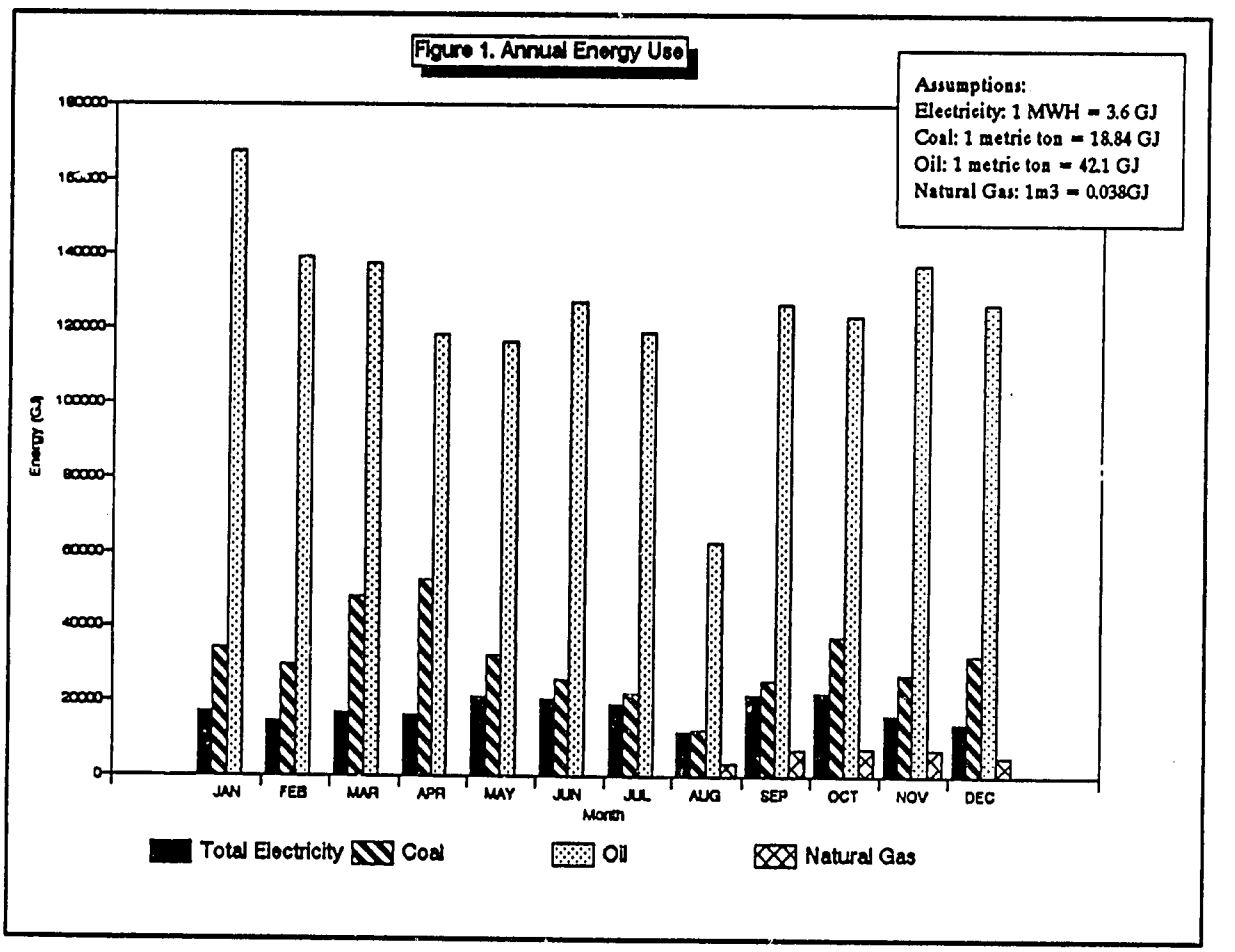


Figure 2. Electrical Consumption

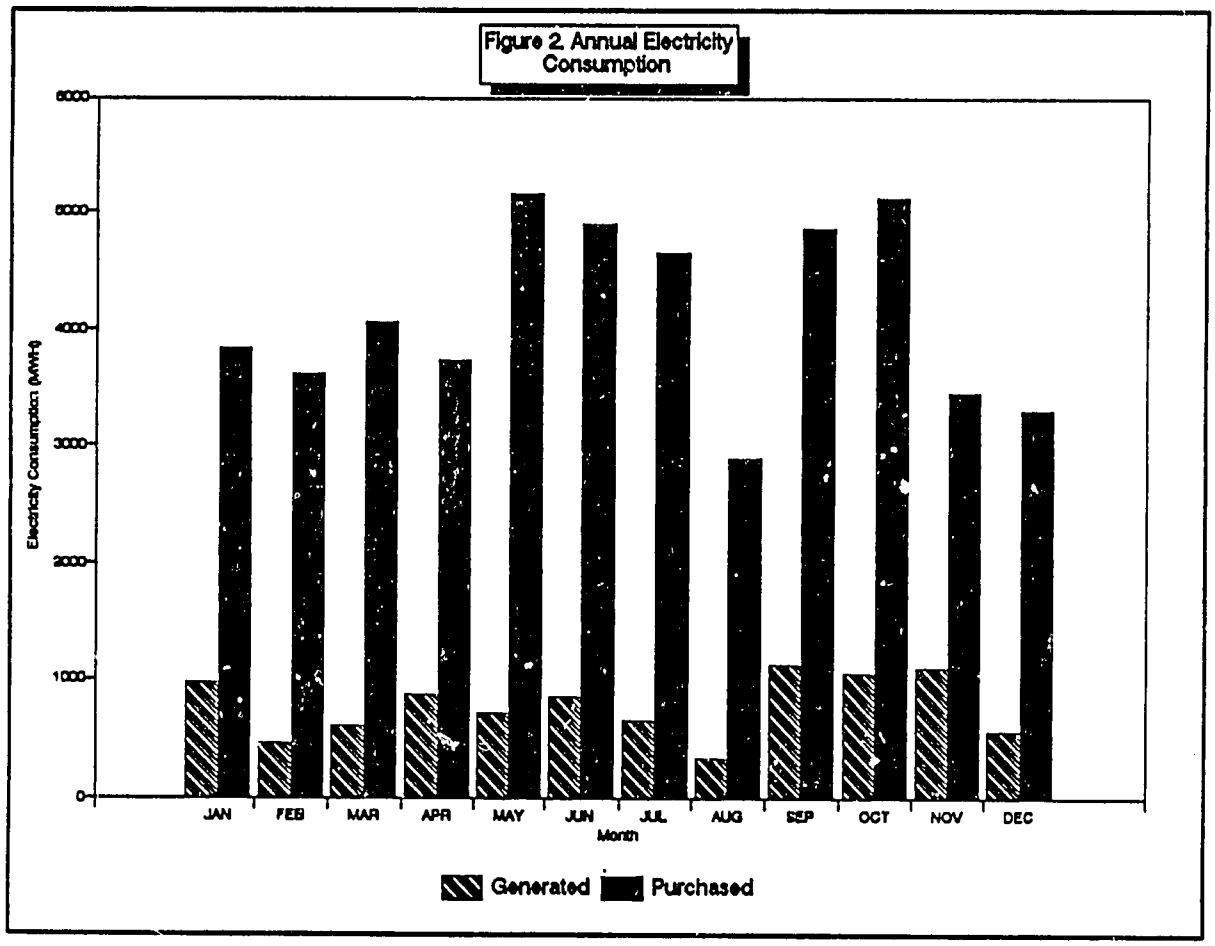
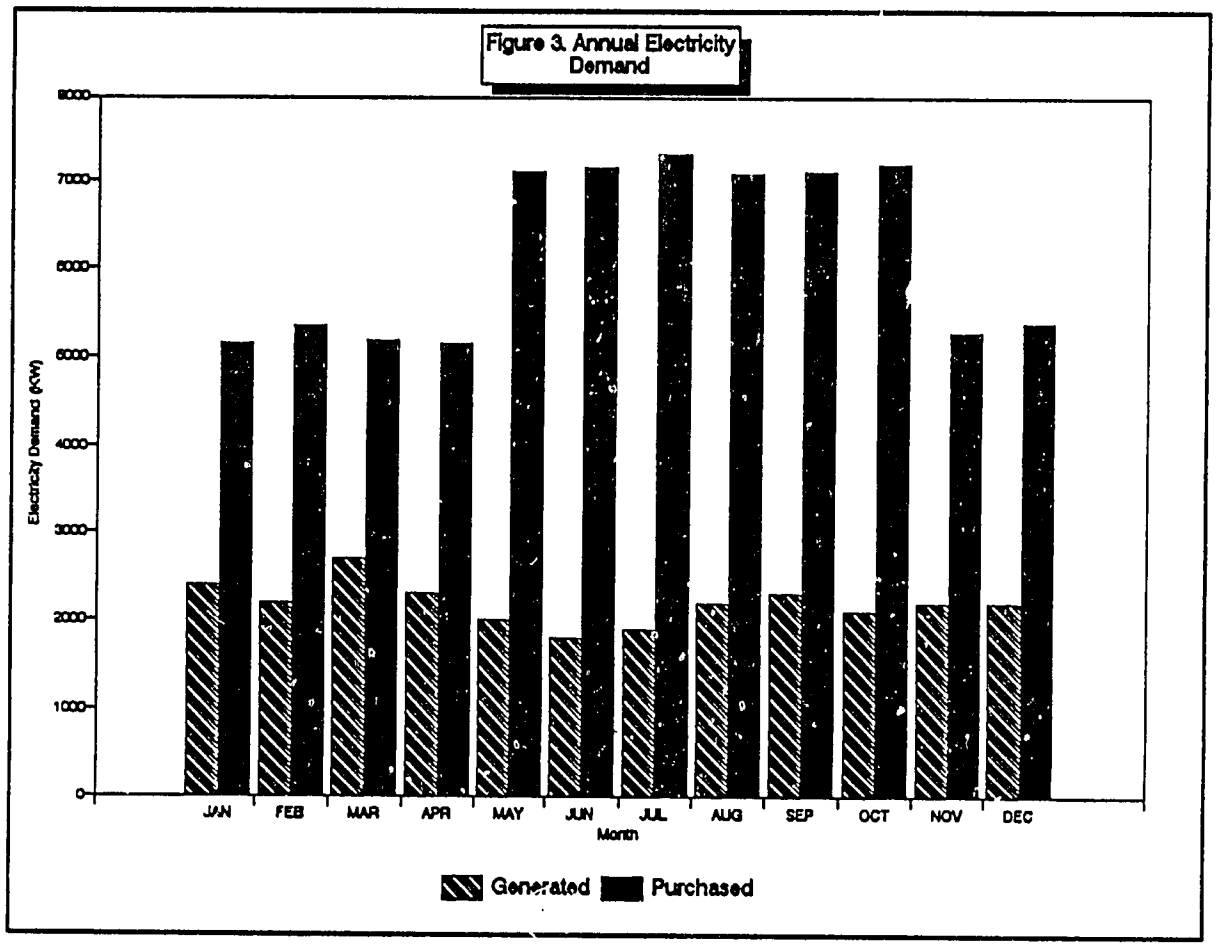


Figure 3. Electrical Demand



Steam requirements for the processes (technologies) are relatively constant, although surges in demand caused by fermentation tank sterilization operations seem to be a problem. Steam use by the space heating systems are affected by weather conditions. There seemed to be an attitude that regarded the space heating system as a sink into which the excess steam from the compressors could be condensed. Thus, until building spaces got too warm, the heating water temperature was maintained higher than necessary. Since there are no heating control valves in most spaces, this results in overheating and temperature control by opening of windows. This was to allow the operation of the second steam air compressor as long as possible.

Maximum electrical demand is about 9,200 KW, annual consumption is almost 58,000 MWh/year. Fifteen percent of this is internally generated. Load factors for purchased electricity are high, over 92% in the winter, but decrease in the summer due to the use of electric air compressors. Annual load factors for 1990 were down to 77% due to one turbine being out of service for the latter part of the year. Total load factor is about 73% for the year, although it is not clear that maximum demands for the two sources, purchased and self-generated, are coincident.

The major use of both steam and electricity is in the process or technology area. Over 66% of the steam produced and 39% of the electric energy goes directly into the process. Five percent of the energy content of generated steam is used to produce compressed air and about 10% of the electricity. Other major users are in producing the steam and electric power, in preheating feed water, water treatment, and water pumping. Building heating and service water accounts for only 6% of the steam use. Lighting is estimated to be less than 10% of the electric use. *In Figure 4* the energy use distribution is illustrated to show comparative levels of energy use. *Figure 5*, Energy Cost Distribution, shows the same information in terms of costs. (*Figure 5* is based on 1990 use with April 1991 costs). Finally, *Figure 6*, Energy Use By Product, is a somewhat more detailed breakdown of energy use by product. It should be recognized that this does not include energy used for producing compressed air, by either electricity or steam.

Figure 4. Energy Use Distribution

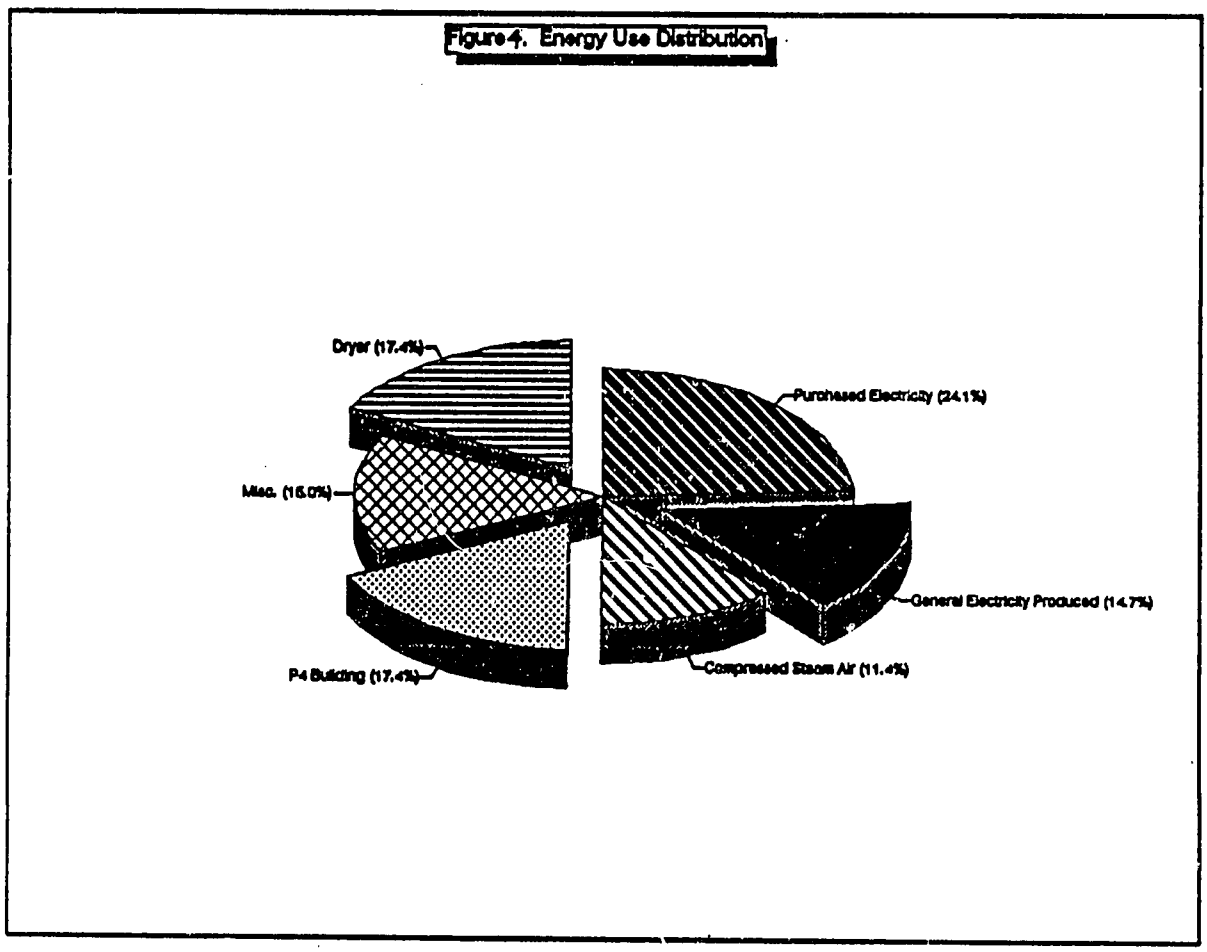


Figure 5. Energy Cost Distribution

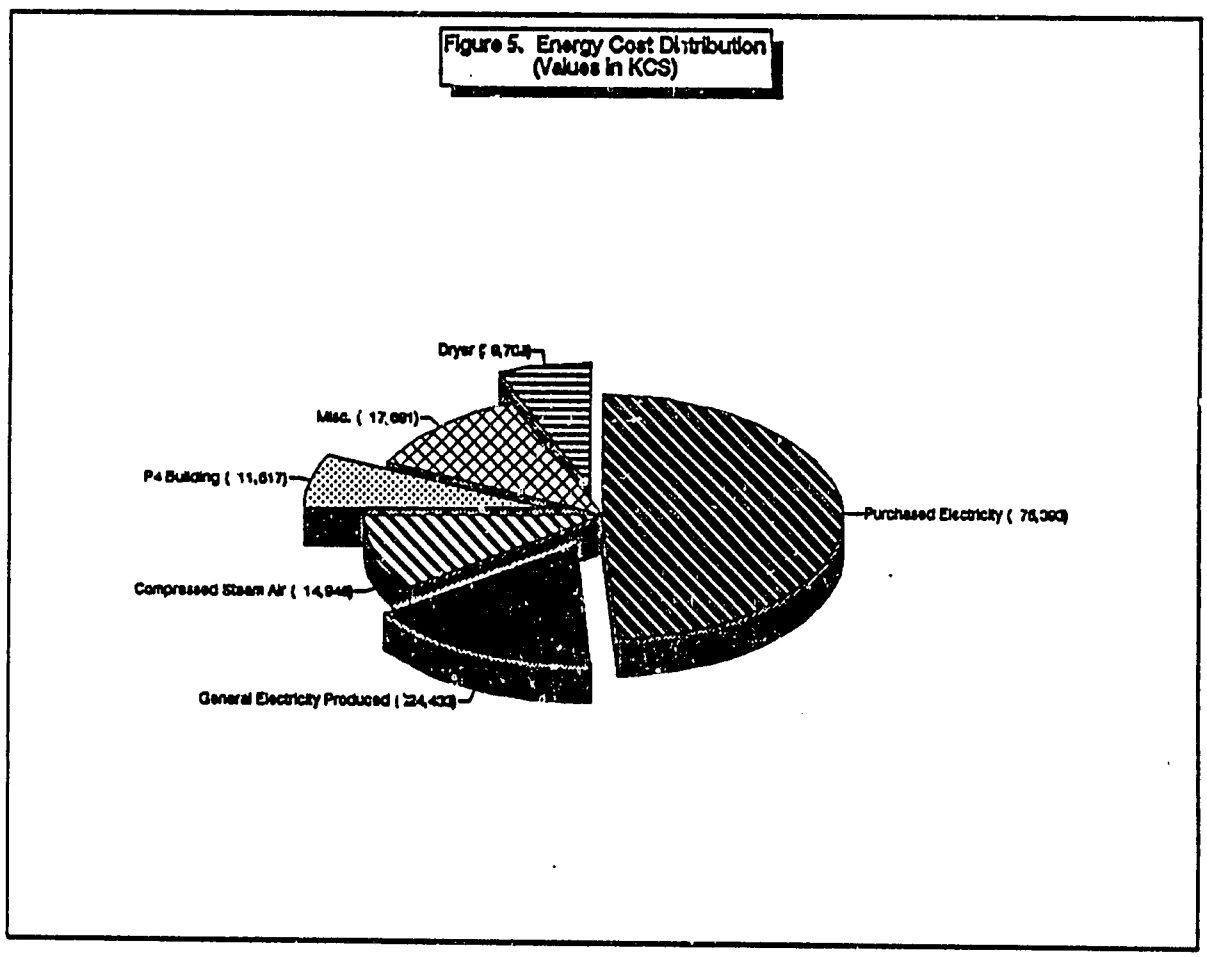
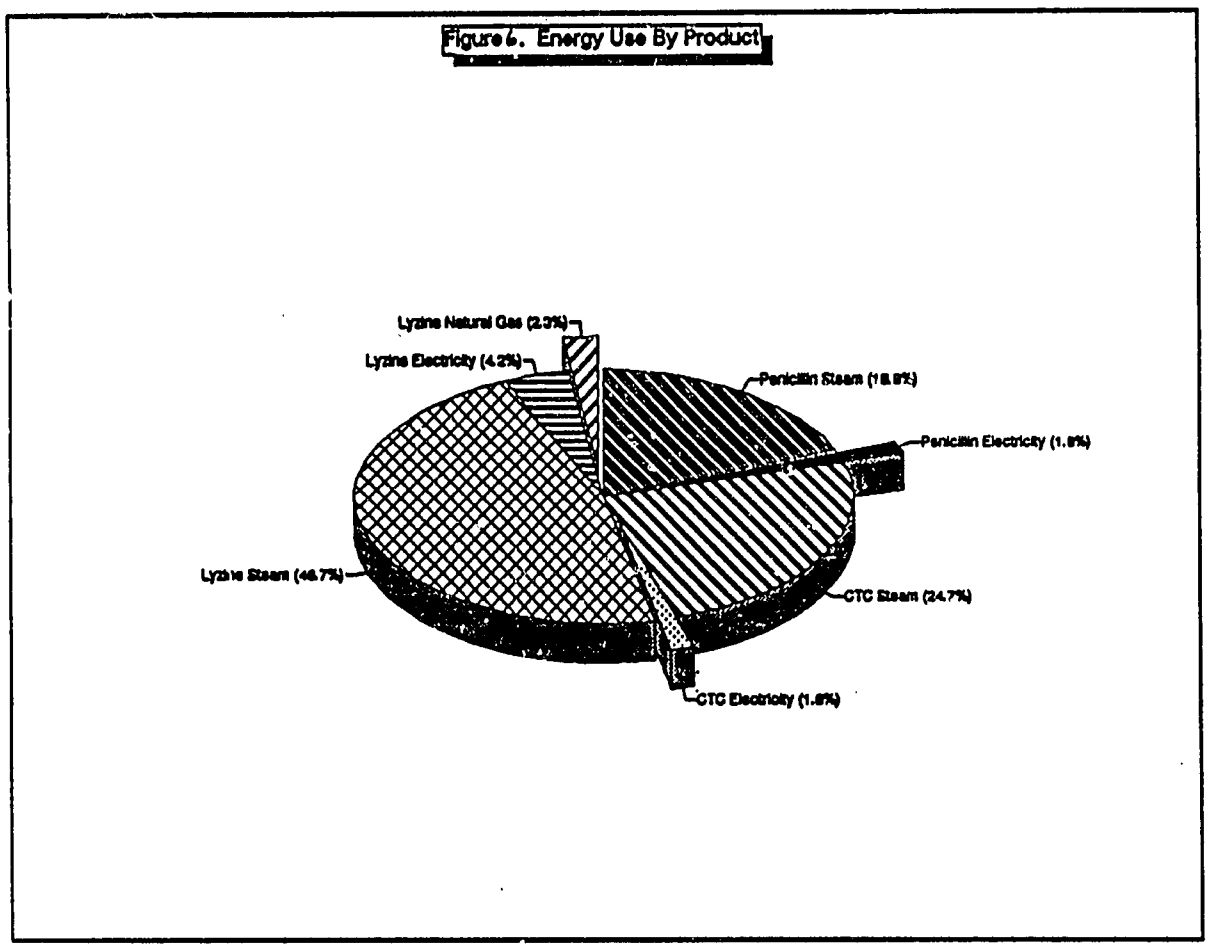


Figure 6. Energy Use By Product



4.0 Audit Description

The audit at the Biotika Pharmaceutical Plant began on March 25 and was completed on March 29, 1991. The first day was spent touring the plant and receiving briefings by plant authorities on energy usage and the various processes in the plant. The central steam plant was also toured and the energy flows explained.

In the course of the plant tour, several possible energy conservation measures were observed. Most of the second day was spent discussing these measures with the plant staff. Among the possible energy conservation opportunities discussed were:

1. Use of energy efficient motors - Many electric motors, ranging in size from fractional horsepower to 350 kW (470 horsepower) are in use in the plant. Most are over ten years old in design and construction. The audit team felt that replacing some with modern high efficiency motors would be energy efficient. However, after reviewing manufacturers data, most motors were found to be over 90% efficient.

2. Replacement of multiple V-belt drives with 'cog' belt drives - Many multiple, up to 24 belts, V-belt drives were in use. A principle area of use was for large motors (200-350 kW) driving mixers in the large fermentation tanks. Use of cogs, or positive drive belts, can produce a transmission efficiency improvement from 85% to 88% to over 96%. In addition cog belts last longer, are quiet and do not slip. In discussion with plant personnel, however, it was found that many such drives were in the process of being replaced with gear drives, with the approximate efficiency of 92% to 95%. Over 45 had already been purchased, although not yet installed. The cog belt drive system would be an energy reduction versus gear drives, in addition to being much quieter.

3. Control of excess combustion air for boilers - The existing boilers, especially the coal fired boilers, are operating with excessive combustion air. There is no ready method for controlling underfire air. The plant has plans to install dampers with O_2 sensor controllers in conjunction with a boiler plant computerized control system.

4. Variable speed drives for mixing motors - Variable frequency drives could be used to reduce energy consumption by the fermentation tank mixing motors and optimize processes. The plant is installing two-speed motors on many of the fermentation tanks in conjunction with the installation of gear drives. This was felt to be adequate, although they may experiment with variable speed.

On the third day, the heat spy infrared thermometer and acoustic flow meter were demonstrated. The heat spy thermometer successfully identified several steam traps which were leaking. It was also used to check surface temperatures of fermentation tanks. The acoustic flow meter was used to measure sucrose solution flow to the fermentation tanks and fuel oil flows. An attempt was made to measure cooling water flows but was unsuccessful due to the clarity of the water. Wash waters and condensate from sterilization of fermentation tanks was readily measured.

Combustion tests were performed on the Number 4 oil fired boiler with the combustion analyzer. Results were inconsistent with very low stack temperatures, high excess air and O_2 After trying several locations, including above the combustion air recuperator, a severe air leak was discovered. This was increasing flue gas flows by about 25%, resulting in increased electrical consumption by the induced draft motor, decreased efficiency due to less heat recovery in the combustion air recuperator and the possibility of severe stack corrosion due to flue gas condensation. Boilers 1, 2, and 3 were combined coal and oil fired and the preset fuels in the combustion analyzer did not match the combined fuels being used. In addition, the probe on the analyzer was too short for this size boiler. (This is true for the boiler tested also.) The results indicate that regular combustion analysis can identify problems and reduce energy consumption. Although it was not possible to tune the boiler due to the air leak, which could not be repaired in the time available, indications were that significant reductions in excess air were possible. This would result in a 2% to 3% improvement in combustion efficiency.

5.0 Summary of Results

In general the plant was found to be in excellent condition; most low-cost/no-cost energy conservation measures had been accomplished by the plant staff. In October 1990, the plant embarked on a campaign of steam trap maintenance and leak repair. This campaign was very successful, reducing product energy costs by over 15%. Other measures also had been taken, including switching from steam to natural gas in the amino acid drying process. The low-cost measures left to be accomplished were either scheduled for the annual plant shut-down in July, or were higher cost measures, which require plant budget authorization.

The following ECO's were identified by the audit team for USAID demonstration project funding.

5.1 ECO's Recommended for Demonstration

1. Installation of Space Heating Controls for the Main Administration Building.

Current Situation: The main administration building is heated with hot water circulating through coils embedded in the ceilings - "ceiling radiant heating". The amount of heat supplied to the building is controlled manually by opening or closing valves on the two hot water supply mains; the manually controlled valves are adjusted in accordance with the outside air temperature and the valve operator's experience and judgement. Overheating of the building is common and the "open window" method is used to compensate for overheating. However, the open window method is only partially effective for controlling comfort since the warm ceiling continues to radiate heat regardless of the air temperature. This situation is similar to sitting in front of a fireplace on a cold evening.

As measured by the audit team, the heated ceiling temperature was 43 °C (109 °F). Even with open windows, the room felt warm and uncomfortable. It was reported that many complaints have been received regarding overheating and it is acknowledged by management that the heating system "is not good".

The main administration building has three floors plus a full basement; only 50% of the basement area is heated. The total heated area of the building is 2,663 square meters (28,664 sq ft). Windows are all double glazed, well weatherstripped and in good condition. The walls are solid masonry about 0.5 meters thick with no insulation.

Approximately 45% of the ground floor is allocated to a kitchen/dining area for plant employees and is operated 24 hours per day, 7 days per week. The remainder of the building is office space used one shift per day, 5 days per week. Consequently, the whole building is heated 24 hours per day, 7 days per week, even though 85% of the building is on a one shift/5 days per week schedule. Temperature set back for evening and weekends is not possible with the current heating control system, or more appropriately, the lack of a control system.

The installation of an automatic space heating control system will result in an estimated savings of 35% of the building space heating requirements, or 917 GJ of savings for space heating by:

1. controlling space temperatures within a specified range, e.g. 20-22 °C, (68-72 °F);
2. eliminating the overheating; and
3. allowing for temperature set back for 85% of the building during evening and weekend periods.

Recommended ECO: Install a programmable computer-controlled heating control system, with appropriate thermostatically controlled valves for space heating of the Administration building. The system will be designed with two heating zones, one for the kitchen/dining area and the other for the offices in the remainder of the building. The system will allow for the following operations:

1. Automatic control of the heat supplied to the two zones in accordance with outside air temperature.
2. Automatic temperature control for all parts of the building.
3. Programmable scheduling of temperature setbacks (and for reheating) for the individual zones; schedules for each zone can be set independent of the other.

It was also recommended that the computer control station be equipped with expandable control points. Upon successful demonstration of the energy savings for the Administration building, Biotika could readily extend the computer system to the following buildings that have the same type of heating control as the Administration building. These include:

- four laboratory buildings
- two apartment buildings
- one office building
- one social services building
- one buffet building
- one school building

At such time that the computer control system is extended to the above buildings, Biotika would be responsible for the costs of the expansion. However, since the basic control system will already be in place, the additional costs will be minimized.

The specifications for the initial installation of the programmable control system are given in Appendix A.

Estimated Energy Savings: (for only the initial installation for the Administration building):

Estimated 1990 energy consumption for heating - 2,620 GJ@ 171.6 Kcs/GJ - 449,600 Kcs or $16,500

Estimated energy savings for heating -10-15% savings for overheating
15% savings for night/weekend setback
5-10% savings for temperature control at 20-22 °C instead of nominal 23-25 °C
Total estimated savings - 35% or 917 GJ = 157,350 Kcs or $5,825

Estimated cost for equipment - $12,000
Estimated Payback - 2 years

Note 1: The cost includes installation of the computer control system and the purchase of the thermostatic control valves. Biotika, as part of their cost sharing, will pay for preparation of suitable facilities for the computer control system, necessary services and materials for operation of the system and the installation of the thermostatic control valves.

Note 2: The estimated payback for the programmable computer-control system will be reduced to less than one year at such time that Biotika extends the control system to the additional buildings. This could be up to ten buildings.

2. Purchase of test instruments for monitoring and improving energy efficiency of energy consuming equipment.

Current condition: Plant engineering personnel do not have key test instruments for monitoring the performance of energy consuming equipment. For example, the steam boilers are controlled manually and there is no equipment available for setting the combustion at maximum efficiency. Likewise, no equipment is available for monitoring the condition of the hundreds of steam traps; if steam traps were known to be defective, plant personnel would make the necessary repairs. Whereas plant personnel have demonstrated a high level of proficiency in effectively operating processes and equipment in the plant, their abilities are limited by the lack of key test instruments.

Recommended ECO: Purchase of the following test instruments for increasing the operating efficiencies of the steam boilers and natural gas dryers, and for monitoring the performance of components of the steam distribution system (e.g. steam traps and insulation):

- 1 portable combustion analyzer
- 1 portable liquid flow meter
- 2 hand-held infrared thermometers

Specifications for the listed test instruments are given in Appendix B.

Estimated Energy Savings: Estimated savings are based on observations by the audit team; e.g., combustion analysis, infrared thermometer measurements of trap discharge temperatures, and flow measurements of fuel oil flow; discussions with plant personnel; and technical experience of the audit team with similar operations.

- 1-3% savings of fuel to boilers by optimizing fuel combustion.
- 2-4% savings of steam by timely repair of steam traps and insulation.

Total Estimated Savings:

2% of boiler fuel use (2,027,716 GJ)	40,554 GJ
3% of steam produced (1,703,281 GJ)	51,098 GJ
Total	91,652 GJ

at 171 Kcs/GJ; 15,626,835 Kcs or $558,101

Estimated cost for instruments: $12,000

Estimated payback: less than 1 month

3. Information and Technical Specifications for Energy Conservation Related Equipment and Software.

Current Condition: The technical staff is well trained and has a high awareness of plant needs for implementing many major energy conservation measures. However, they have not been exposed to newer western technologies and equipment, and consequently their analyses and design abilities are limited. Data on newer western products including technical specifications, pricing, and availability, would be useful. With such information, technical staff would be able to identify items that would meet their requirements and where applicable, purchase the items. It should be understood that this ECO involves only supplying information, not the purchase of the items. It will be the responsibility of Biotika to purchase the items.

Recommended ECO: That RMA acquire and transfer technical and pricing information to Biotika for the following equipment:

- Steam BTU meters for low and high pressure systems.
- (Liquid) and gas flow meters; typical liquids include hot water/steam condensate, cooling water, and processing liquids and slurries.
- Infrared "thermovision" imaging equipment.
- Design/analyses software for 286/386 PCs, e.g. steam system design, steam trap sizing/selection, piping design, and energy management, etc.

Estimated Cost Savings: not determinable

6.0 Plant Energy Management/Organization

Biotika has a strong vertically structured energy awareness and conservation management team headed by the Technical and Investment Director. They have implemented many major modifications to the processes and equipment and have experienced first-hand the advantages and savings resulting from these actions. The results of these efforts are among the best the audit team has seen not only in Czechoslovakia but also in the United States. Although the energy management and conservation efforts have not been formalized within the management structure, it was apparent that energy availability, costs and environmental effects are among the top priorities. Specific examples of this follow:

- Ever increasing energy costs are recognized as a threat to their domestic and international competitive position.

- Reliability of energy supplies is critical to assure continuous operations. Interruption of energy supply would represent major losses of products in progress. Efforts are being made to assure such reliability, even at the expense of increased energy costs, by operating standby energy supplies.

- Due to the uncertainties regarding future availability of major fuel supplies and energy cost structures, the strategy is to develop multiple fuel utilization capabilities and continue to maintain self-generated and purchased electrical power options.

- Environmental impacts of burning brown coal and heavy oil are of serious concern to the management, and to this end, natural gas is the preferred fuel for steam generation. However, unless firm supplies of gas can be obtained, the coal and oil options must be used. As yet there are no plans to install pollution control measures on the boiler plants.

The management has developed a prioritized approach to implementing energy conservation measures that: 1) have significant savings of energy costs and payback in less than 1-2 years; 2) increases the reliability of energy supply/distribution; and 3) improves the quality of their products.

The management documents most every aspect of their energy costs and utilization. However, some improvement in their documentation could be made by the installation of steam meters and condensate flow meters.

One area that appeared lacking in the overall energy conservation program was the inclusion of all the workers in an energy conservation awareness program. Incentives should be provided for plant staff participation.

7.0 Implementation Assessment

Date visited: July 31, 1991

Contacts: Mr. Zdeno Kadlcik and staff of the Energy Department.

Objectives of visit:

1. Determine the status of equipment delivered to Biotika.
2. Evaluate the status of the demonstration project.
3. Assist in the preparation of Biotika presentation at the August 15, 1991 seminar.
4. Assess the status of other energy conservation measures undertaken by Biotika.

7.1 Status of Equipment

During the visit it was verified that Johnson Controls, Inc. (JCI) had delivered all required equipment for the computer-controlled space heating system and that the system was completely installed and ready for operation. The installation of the equipment included:

1. Installation of electrical services by Biotika.
2. Installation of valves, control elements and the computer system by JCI.
3. Installation of the operating software by JCI.
4. Installation of the computer/monitor in the Power House control room so that system operation will be monitored 24 hours per day, seven days per week. The installation was completed through the joint efforts of JCI and Biotika.

Photographs of the various components of the installed computer-controlled space heating system are shown in photographs 1, 2, and 3 in Appendix D. These photographs include the Johnson Controls sensors and valves (photo 1), a computer in the Central Plant Control Room that monitors the valves (photos 2 and 3).

Informal training of plant personnel on the operation of the system was provided by JCI during the installation phase; formal training was provided by JCI in mid-August and a refresher course was given at the beginning of the heating season (about mid-October).

During joint discussions with JCI and Biotika, the terms and conditions of the equipment warranties were reviewed and understood by all parties; specifically, JCI will warrant the equipment for twelve months starting at the beginning of operation during the 1991 heating season and will provide a service contract for the same time period.

Biotika agreed to send to RMA a letter stating the equipment was received and installed to their satisfaction.

The test instruments were delivered to Biotika coincident with the visit. The test instruments were unpacked and were found to be complete and operational. The operation and uses of the test instruments were reviewed with the plant personnel.

7.2 Status of the Demonstration Project

The objectives of the demonstration projects are:

1. To reduce the steam required to heat the Administration Building by use of computerized controls and thermostatic valves.

2. To increase the operating efficiencies of combustion equipment and steam distribution systems by use of test instrumentation.

The equipment for demonstration of the computer-controlled space heating system is completely installed; demonstration of the system began with the beginning of the 1991 heating season, approximately mid-October and continues throughout the heating season.

Use of test instrumentation to monitor combustion efficiencies and steam distribution systems began the week of August 5, 1991. These efforts will be ongoing. However, it is expected that tangible energy savings were realized within the first month of testing.

Plant personnel agreed to supply test and energy savings data from the demonstration projects to RMA upon request.

7.3 Preparation for the Seminar

Assistance was given to the speaker in outlining the presentation and drafting of the graphics to be used during the presentation. Draft copies of the graphics were sent to SEVEn for final preparation.

7.4 Status of Energy Conservation Measures

As a result of the recommendations of the audit team and the implementation of the demonstration project computer-controlled space heating, Biotika is planning to expand the computer control system provided under the demonstration project to control space heating of ten additional buildings. The additional buildings include office and laboratory facilities.

The costs for the additional equipment and installation will be paid by Biotika. It is anticipated that the energy savings resulting from the installation of the space heating control systems in each of the additional buildings will be similar to the savings realized from the demonstration project for the Administration building.

APPENDIX A
Specifications for Programmable Computer Control System

Point of contact:

Zdeno Kadlcik, Technical and Investment Director
Biotika, s.p.
97613 Slovenska Lupca
Telephone: 088 553
Telex: 070220

Equipment specification:

A complete programmable computer space heating control system, capable of controlling the two heating zones in the Administration building to preset schedules and space temperatures. The system will include a PC computer, control unit, control valves, thermostatic control valves, necessary software and all other components to create a functioning system. Biotika will be responsible for providing all supporting services and the installation of the thermostatic control valves. The supplier will be responsible for installing the control system and valves, commissioning the system and training Biotika personnel in the operation of the system.

In-country representatives of two suppliers, Johnson Controls and Honeywell, have agreed to prepare detailed specifications in cooperation with Biotika staff the week of April 1, 1991, and submit their respective quotations by the following week to RMA via the SEVEN office, Prague.

APPENDIX B
Specifications for Purchase of Test Equipment

Point of contact:

Zdeno Kadlcik, Technical and Investment Director
Biotika, s.p.
97613 Slovenska Lupca
Telephone: 088 553
Telex: 070220

Equipment specifications:

All items should have, where applicable:

- full operating instructions, two copies if possible;
- battery chargers or other electrical connections set for 220 volts, 50 hertz operation;
- maximum reliability under industrial plant conditions;
- spare parts and extra expendable materials, especially those that may break easily, e.g. glass parts;
- warranties extendable to Biotika, and instructions for obtaining servicing; and
- technical support literature that describes the uses and limitations of the instruments.

Item 1, one portable combustion analyzer: as supplied to the audit teams (minus the modem feature) or equivalent.

Item 2, one portable liquid flow meter (minus the print-out feature): as supplied to the audit team or equivalent. If a unit having greater sensitivity for clean water were available, it should be specified.

Item 3, two infrared thermometers ("Heat Spy") as supplied to the audit team; maximum temperature - 2,000 °F.

APPENDIX C
Acquisition of Technical Literature

Point of contact:

Zdeno Kadlcik, Technical and Investment Director
Biotika, s.p.
97613 Slovenska Lupca
Telephone: 088 553
Telex: 070220

Information requirements:

Acquire and assemble technical and pricing information for the listed items. Vendors having sales representation in Europe (and preferably eastern Europe), should have highest priority. If possible, vendor support information/papers/data should be included.

Areas of interest:

- liquid and gas flow meters, both indicating and recording.
- steam /BTU meters, for both low and high pressure.
- infrared "thermovision" imaging equipment.
- PC software (286/386) for all aspects of energy system design, sizing of steam traps, piping, etc., and energy analyses.

APPENDIX D
Photographs

1. Johnson Controls sensors and a valve which controls the mixing of water to administrative buildings.

2. A Computer in the Central Plant Control Room. Over the next 2 years, they will expand to 11 buildings. From left to right: A Service Representative for Johnson Controls, Mr. Vagner, Mr. Puskailer (Director of Computer Systems and Programming), Mr. Anderson (RMA), Mr. Revallo (Electroprojekt) and Mr. Tichy.

3. Computer in the Central Plant Control Room. The computer display shows temperatures and the position of valves. Mr. Puskailer (left) and Mr. Erickson (RMA).

APPENDIX E
List of Abbreviations

AC	= alternating current
amps	= amperes
atm	= atmosphere = 14.696 pounds per square inch
bar	= 100,000 pascals = 14.504 pounds per square inch
BTU	= British thermal unit
cfm	= cubic feet per minute
cm	= centimeter = 0.3937 inches
cm^2	= square centimeter = 0.155 square inches
CO	= carbon monoxide
CO_2	= carbon dioxide
DC	= direct current
°C	= degree Celsius T[°C] = 5/9*(T[°F] - 32)
°F	= degree Fahrenheit
°R	= degrees Rankine T[°R] = T[°F] + 460
eff	= efficiency
ex air	= excess air
Gcal	= gigacalorie = 1 billion calories = 3.968 million BTU
GJ	= gigajoules = 1 billion joules
gph	= U.S. gallons per hour
gpm	= U.S. gallons per minute
GWh	= gigawatt hours = 1 billion watt hours
H_2	= hydrogen
H_2O	= water
H_2SO_4	= sulfuric acid
hectare	= 10,000 square meters = 2.471 acres
hectoliter	= 100 liters = 26.42 U.S. gallons
Hg	= mercury
hr	= hour
Hz	= hertz = cycles per second
J	= joules
K	= Kalvin
kcal	= kilocalories = 1 thousand calories = 3.968 BTU
Kcs	= 29.77/$1 US
kg	= kilogram = 2.2046 pounds
Kgcc	= 7,000 kcal = 27,776 BTU
kJ	= kilojoules = 1 thousand joules = 0.947813 BTU
km	= kilometer = 0.621 miles
kN	= kilonewton = 1 thousand newtons
kPa	= kilo pascals = 1 thousand pascals = 0.14504 pounds per square inch
kV	= kilovolts = 1 thousand volts
kVa	= kilovolt-amperes
kVAr	= kilovars = 1 thousand volt-amperes (reactive)
kW	= kilowatt = 1 thousand watts
kWh	= kilowatt hour = 1 thousand watt hours
lbs	= pounds
liter	= 0.2642 U.S. gallons = 0.03531 cubic feet
m	= meter = 39.37 inches
m^2	= square meter = 10.76 square feet

m^3	= cubic meter = 35.31 cubic feet
mA	= milliampere = 0.001 amperes
MCal	= megacalorie = 1 million calories
metric ton	= 1 thousand kilograms = 1.1023 U.S. tons
mg	= milligrams
min	= minute
MJ	= megajoules
mm	= millimeter = 0.03937 inches
MPa	= 1 million pascals = 145.04 pounds per square inch
MVA	= megavolt-amperes
MW	= megawatt = 1 million watts
MWh	= megawatt hours = 1 million watt hours
NG	= natural gas
nm	= nanometer
Nm^3	= cubic meters at standard conditions of temperature and pressure (20 °C and 1 atmosphere)
NO_X	= nitrogen oxide
O_2	= oxygen
P	= pressure
PC	= personal computer
PF	= power factor
ppm	= parts per million
psi	= pounds per square inch
psig	= pounds per square inch (gauge)
R	= thermal resistance
s	= second
SO_2	= sulfur dioxide
sq ft	= square feet
Tcal	= teracalorie = 1 trillion calories = 3.968 billion BTU
T	= temperature
V	= volts
VArs	= volt-amps (reactive)
VSD	= variable speed drive
W	= watts
yr	= year