PN-ABL-024
76999

ENERGY EFFICIENCY AUDIT REPORT
BALKAN RUBBER AND CHEMICAL INDUSTRY
SUVA REKA, YUGOSLAVIA

MARCH 1992

PREPARED BY: RCG/HAGLER, BAILLY, INC.
Arlington, VA

and

TEKON Tehno-Konsalting
Belgrade, Yugoslavia

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

U.S. AGENCY FOR INTERNATIONAL DEVELOPMENT
BUREAU FOR EUROPE
WASHINGTON, D.C. 20253

ENERGY EFFICIENCY AUDIT REPORT
BALKAN RUBBER AND CHEMICAL INDUSTRY
SUVA REKA, YUGOSLAVIA

MARCH 1992

PREPARED BY: RCG/HAGLER, BAILLY, INC.
1530 Wilson Boulevard
Suite 900
Arlington, VA 22209
(703) 351-0300

and

TEKON Tehno-Konsalting
Lenjinov Bulevar 123
Belgrade, Yugoslavia
(3811) 145-367

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. 20253

USAID Contract EUR-0015-C-00-1007-00

DISCLAIMER

The contents of this report are offered as guidance. RCG/Hagler, Bailly, Inc., TEKON Tehno-Konsalting, and the United States Agency for International Development, and all technical sources referenced in this report do not (a) make any warranty or representation, express or implied, with respect to the accuracy, completeness, or usefulness of the information contained in this report, or that the use of any information, apparatus, method, or process disclosed in this report may not infringe upon privately owned rights; (b) assume any liabilities with respect to the use of, or for damages resulting from, any information, apparatus, method or process disclosed in this report. This report does not reflect official views or policies of the above named institutions. Mention of trade names or commercial products does not constitute endorsement or recommendation for exclusive use.

QUALITY ASSURANCE

The contents of this report include recommendations based on data provided by the client plant, measurements made on site, calculations, and engineering judgment. The conclusions reached were based on a limited engagement of only about one week's duration in the plant, and not an exhaustive engineering analysis. RCG/Hagler, Bailly, Inc. certifies that this report conforms to the level of best commercial practice for industrial energy audits of similar level of effort, as conducted in the United States. This report has been prepared under the guidance of a registered Professional Engineer, licensed to practice in the United States.

PRELIMINARY ENERGY AUDIT
BALKAN RUBBER AND CHEMICAL INDUSTRY

CONTENTS

DESCRIPTION		PAGE
I.	EXECUTIVE SUMMARY	1
II.	PLANT DESCRIPTION	3
III.	ENERGY CONSUMPTION AND EFFICIENCY	5
IV.	ENERGY CONSERVATION RECOMMENDATIONS	7
A.1	BEGIN ENERGY ACCOUNTING/MONITORING PROCEDURES	9
A.2	IMPROVE BOILER COMBUSTION EFFICIENCY	12
A.3	SET UP STEAM SYSTEM EFFICIENCY TEAMS	15
A.4	REDUCE PEAK DEMAND	18

ACKNOWLEDGEMENTS

RCG/Hagler, Bailly, Inc. and TEKON gratefully acknowledge the assistance and hospitality provided by Mr. Vekoslav Sosevic, General Manager, and his staff during the period of the preliminary energy audit.

EXECUTIVE SUMMARY

This report presents the results from a partial preliminary energy audit carried out by a team of engineers from RCG/Hagler, Bailly, Inc. and TEKON Tehno-Konsalting at Balkan Rubber and Chemical Industry, Suva Reka, Yugoslavia from March 12 through March 15, 1991. The objectives of the audit were to work with the plant staff to: evaluate energy consumption at the plant; determine the level of energy management practiced; to identify energy conservation actions or opportunities; and identify instrumentation and low-cost equipment needed by the plant to implement the more attractive energy conservation actions. Due to the tense political situation at the plant during the audit visit, the audit team was severely constrained in making measurements and obtaining operating data. The results of this report are based on the small amount of general data collected during this time.

Primary products of the plant are rubber belts of all sizes, produced mainly as conveyor belts and V-belts. An estimated summary of the annual primary energy consumption at the plant based on 4 months of data (November 1990 through February 1991) for fuel oil and only one month of data (March 1991) for electricity data is given below (a terajoule, TJ is 10^{12} Joules). Actual cost information was not available; costs are based on typical U.S. prices ($0.08/kWh; $130/tonne fuel oil).

		Energy Distribution		Cost Distribution	
	actual units	TJ	%	US $	%
Electricity	7,000 MWh	84	22	560,000	37
Heavy fuel oil	7,400 tonnes	300	78	960,000	63
TOTALS		384	100%	1,520,000	100

Balkan has not focused much effort on reducing its energy consumption, due to more serious problems at the plant, both political and financial. As a result, there are good potential savings in improved energy management, monitoring, and maintenance. A more detailed audit would most likely identify possible process-related energy conservation measures as well.

During the brief preliminary energy audit work on site, Krka staff worked with the audit team to identify additional energy efficiency measures. Based on the discussions with management, production and technical staff, inspection of equipment and operating procedures, analysis of plant energy and production data, and measurements of

certain process parameters, a list of energy conservation actions have been identified. These are summarized below.

Action ID	Recommendation	Costs (US$) Equipment	Duties & Instln Costs	Energy Savings	Years Simple Payback
A.1	Energy accounting/monitoring	15,000	0	20,800	0.7
A.2	Boiler efficiency improvement	4,000	2,500	19,200	0.3
A.3	Steam system efficiency teams	10,000	2,500	48,100	0.3
A.4	Reduce peak demand	0	0	25,200	0
	TOTALS	29,000	5,000	113,300	0.3

CHAPTER 1 -- PLANT DESCRIPTION

Balkan in located in Suva Reka in the autonomous province of Kosovo. It is a medium-sized rubber producer, manufacturing rubber belt material for V-belts and conveyor belts. It is fifth in size among rubber plants in Yugoslavia.

Balkan operates the typical equipment used for rubber production, such as large mixers, extruders, and vulcanizing machines. Specialized rollers are used to make the various belts. In addition, a small weaving plant produces rayon fabric which is used to reinforce the belts. Steel reinforced belts are also produced.

The preliminary energy audit was limited to a walk-through visit to most of the facilities. No measurements were taken.

1.1 Steam Generation

Balkan has five Djuro Djakovic firetube boilers of various capacities, totaling approximately 60 t/h. Less than half this capacity is normally used. Most of the boilers have automatic load control; boiler efficiencies are not measured.

1.2 Steam Distribution

Steam is distributed throughout the plant at approximately 7 bar. The main use of steam is in the vulcanization process. Steam metering stations were installed for all the major departments approximately 10 years ago. There is no evidence that they were ever used. They are in poor condition now, and would need to be refurbished before they can be useful.

The steam system also suffers from lack of maintenance. Steam leaks should be repaired, and insulation upgraded.

A condensate return system exists, but it could not be determined how much condensate is actually returned. Steam traps in general are in poor condition, and as a result, sometimes affect process temperatures.

1.3 Electricity Generation/Distribution

There are two major electricity consumers: the mixer motors and the air compressors. There are three mixers, two of 736/369 kW and

one of 1250/900 kW. Each mixing station also has one 200 kW motor. The air compressor motor sizes range from 60 to 100 kW each.

CHAPTER 2 -- ENERGY CONSUMPTION AND EFFICIENCY

In the following sections, some brief comments on energy consumption, production, and energy management are presented.

2.1 Energy Consumption and Production

Heavy fuel oil consumption was obtained for four months, November 1990 through February 1991. In addition, total annual production was available for the same months, as well as for the previous three years.

Period	Mazout (tonnes)	Production (tonnes)	Specific Energy Consumption (t prod per t mazout)
1988	--	9,090	--
1989	--	8,780	--
1990	--	8,310	--
Nov 1990	670	--	--
Dec 1990	610	704	1.15
Jan 1991	556	765	1.38
Feb 1991	635	811	1.28

Electricity consumption was not available during the site visit. Later, consumption for March 1991 was obtained: 579,000 kWh with a demand of 2,100 kW.

2.2 Energy Consumption and Production

The analysis of energy consumption and production data provides a good perspective on the operation of the plant. The specific energy consumption ratio in the table above provides an indication of the efficiency of the plant. It is affected by some seasonal variations, as well as the methods of accounting for production. At this point, there is insufficient data to draw any conclusions; however, as discussed below, regular analysis of this data will allow Balkan to better evaluate and understand its energy consumption.

2.2 Energy Management

Given the current political and financial conditions in the plant, energy management is not a priority. A further problem is a large amount of new staff, unfamiliar with the plant. Finally, there is

an overall shortage of workers, which results in many tasks, such as routine maintenance, not to be performed thoroughly, or at all.

While the General Manager is aware of all the problems in the plant, and gets daily reports on production, energy information is not included in these reports. In fact energy is only considered on an annual basis.

CHAPTER 3 -- ENERGY CONSERVATION RECOMMENDATIONS

Despite the short amount of time spent at the plant, a number of actions were clearly identified to help Balkan improve their energy efficiency. The recommendations developed by RCG/Hagler, Bailly for energy efficiency improvement are sorted for convenience into three categories of action:

A. **Energy management improvement actions:** this first category relates to overall energy management, including monitoring, tracking, and regular analyses of energy consumption relative to production. These actions are usually simple, often imply very little cost, and should be implemented as rapidly as possible. Usually these actions require the awareness and experience of the management to filter down to (or to be imposed on) the operator level, increasing their commitment to improve energy efficiency. Examples include improved control of boiler excess air and improved steam system and condensate line maintenance. Some sort of incentive scheme may be usefully applied to obtain more active participation. Actions which fall in this category are coded by "A" preceding the list number. Krka should be able to implement these measures in the next six months, in some cases with assistance from the USAID Emergency Energy Program.

B. **Low-cost and short-term implementable actions:** this second category comprises recommendations usually have paybacks of less than 2 years. Examples of these actions include automated control of combustion efficiency, or improved metering system to allocate steam flow among the major users, providing a better basis for billing and avoiding questions or disagreements on amount of energy used among the different departments. These are also actions in which USAID might be able to participate under this program. Actions of this category are indicated with a "B" preceding a list number.

C. **High cost or long term actions:** this third category and consists principally of technology improvement projects. Actions of this group are shown by a "C" followed by a list number.

Due to the limited time and scope of the preliminary energy audit, measures in the "B" and "C" categories are not considered for Balkan. A longer, more detailed energy audit, which would concentrate more deeply on the process, could be expected to yield additional energy-saving recommendations in this category.

3.1 Presentation of Project Forms

Each project identified by the audit team is presented in a stand-alone project form which provides all basic information to qualify the project. The data are provided at the "inventory" level (first order of magnitude approximation), and include the following:

- Description and rationale
- Calculation of savings (energy and others)
- Implementation cost
- Financial analysis limited to the pretax pay-back period
- Scheduling
- Technical risk and reference
- Equipment specification, if applicable
- Back-up data and calculations, as necessary.

Action A.1 -- Begin Energy Accounting/Monitoring Procedures

1. PROCESS AREA

Overall plant: energy management and accounting system.

2. STATEMENT OF RECOMMENDATION

Develop energy accounting procedures to measure and monitor energy consumption on a daily and a per-production basis. Include such data as the following:

(a) total heavy fuel consumption

(b) steam consumption in the different plants, based on the steam measuring system already in existence

(c) total electrical consumption

(d) submetered electrical consumption by area, where available

(e) daily production data from all the different departments .

This data should be summarized into a few key numbers on a daily basis, or at most on a weekly basis, and presented to the general manager as well as the production and maintenance managers for their review.

Use this system as a management tool to more closely supervise the energy consumption of the various departments relative to their production.

3. DESCRIPTION/RATIONALE

The first key to energy efficiency at Balkan is not necessarily investment in equipment. What is needed is an improvement in the energy utilization, a conscience and awareness of both maintenance and production staff. This effort can only be accomplished with the participation and leadership of top management in the plant.

By quantifying the energy uses, and comparing them to production on a regular basis, the management has a tool to evaluate the performance of the production staff. Over time, statistical data can be developed to account for seasonal variations, changes in production. All this will lead not only to a better understanding of energy consumption at Balkan, but a more motivated staff who

know the management is taking a direct interest in the operation of the plant.

Steam meters have existed for many years at Balkan; however, it has been a long time since they were used. Existing staff is not even sure of the layout of steam piping, since many of them are new to the plant. Over time, this staff should become more familiar with the plant and the equipment. Steam meters can be refurbished, fuel consumption data measured more carefully (and compared to metered steam), and electricity measurements noted regularly. These quantities should be compared to the daily production of different departments; these data are already maintained.

4. BENEFITS

4.1 Energy Savings

Energy savings are obtained as a result of management review of the analyzed data, and the resulting instructions to correct or improve energy use. The installation of a more rigorous energy management/accounting system can be expected to bring anywhere from 0.5 to 3% reduction in energy consumption.

- Assuming 2% reduction in the 7,000 MWh/y electric consumption:

  2/100 x 7,000 MWh/y x 1000 kWh/MWh x $0.08 kWh = $11,200/y

- Assuming 1% reduction in the 7,400 t/y mazout consumption:

  1/100 x 7,400 t/y x $130/tonne = $9,620/y

Total savings are estimated at $ 20,800.

5. IMPLEMENTATION COSTS

An initial data monitoring and analysis system can be started at no cost; the only expense would be the time of one person to organize all the different data required. Eventually, as the system becomes more sophisticated, the cost of refurbishing the various steam meters can cost as much as $10,000 to 15,000.

6. PAYBACK

The payback period, including the cost of steam meters is approximately 0.7 years or 9 months.

7. SCHEDULE

This system should be implemented immediately.

8. TECHNICAL RISK AND REFERENCE

There is no risk involved in the implementation of this project.

Action A.2 -- Improve Boiler Combustion Efficiency

1. PROCESS AREA

Steam generation: combustion control for the all boilers

2. STATEMENT OF RECOMMENDATION

Use a gas analyzer to measure exhaust gas composition of the boilers on a regular basis. For the larger boiler, such a measure should be performed every few days; for the smaller boilers, a weekly measurement will be sufficient. In every case, note the measurements taken and the load of the boiler at the time.

Using the results of these measurements, adjust the mechanical linkages connecting the fuel valve and the air damper on the boilers to reduce or increase the excess air in the system. This activity should be combined with measurement of oxygen and CO or combustibles in the flue gases to ensure that the proper excess air settings are obtained.

3. DESCRIPTION/RATIONALE

All the fuel oil at Balkan, accounting for approximately 2/3 of the energy costs, is used in the boilers. While no measurements of boiler efficiency were taken during the audit, it was observed that the boilers are adjusted manually. While this is usually an adequate adjustment, improvements of 1 to 3% can be made when a more accurate measurement, such as that of a gas analyzer, is used as a basis for adjustment.

4. BENEFITS

4.1 Energy Savings

Energy savings are calculated based on a 2% average improvement of efficiency of heat utilization over all the boilers.

- at 2% average improvement:

7,400 t/y x 0.02 x $ 130/tonne = 19,240 $/y

5. IMPLEMENTATION COSTS

Implementation costs are estimated at a total of $ 6,500, including $4,000 for the analyzer, $2,000 for duties and taxes, and $500 for training of staff and use of the analyzer.

6. PAYBACK

The payback period is approximately 0.3 years, or 4 months.

7. SCHEDULE

Task 1 -- completion date: May 25, 1991

HBI gets quotations from US manufacturers.

Task 2 -- completion date: July 1, 1991

USAID gives clearance for equipment procurement based on HBI financial and economic study and evaluation of quotations.

Task 3 -- completion date: July 8, 1991

HBI sends purchase orders for equipment.

Task 4 -- completion date: August 31, 1991

Shipment of equipment arrives in Yugoslavia. Balkan prepares a workplan for use of the new instrument, including responsibility for its use and maintenance.

Task 5-- completion date: September 20, 1991

Balkan presents results of initial operation tests of the boilers using the new exhaust gas analyzer. Boiler efficiencies are calculated and savings possibilities are evaluated.

Task 6-- completion date: September 20, 1991

HBI reviews Balkan operating procedures and results, and assists in making additional energy-saving recommendations based on the test results.

8. TECHNICAL RISK AND REFERENCE

Proper operation of the instruments presents no risk to the company. As part of the operating procedures mentioned in Task 5, instructions for instrument operation should be translated or

adapted into Serbian, and a detailed training session should be provided to the operators.

9. SPECIFICATION OF EQUIPMENT

Electronic Combustion Gas Analyzer

Type:	Electronic microprocessor-based
Physical:	Portable, self-contained with carrying case Probe length min 12", sample line length minimum 6 ft Silica gel sample dryer and condensate trap Built-in thermal printer, with line feed button
Output:	LCD display, backlit, adjustable - ambient temperature: 0-60 C - stack temperature: 0-600 C - O_2: 0-21%, electrochemical cell - CO: 0-1000 ppm, electrochemical cell - NOx or NO: 0-2000 ppm - SO_2: 0-2000 ppm - Combustibles: 0-2.5%, semiconductor sensor - Stack draft: mmHg, peizoresistive sensor - Computed values of CO_2, excess air, combustion efficiency
Power:	6-12V battery, rechargeable; input 220V 50Hz
Accessories:	memory for various fuels, with possibility to custom set
or Options:	diagnostic messages autozero on startup
Spares:	O_2 cell (1) CO cell (1) 6 rolls printer paper 4 bottles silica gel

Action A.3 -- Set Up Steam System Efficiency Teams

1. PROCESS AREA

Steam and condensate system throughout the plant

2. STATEMENT OF RECOMMENDATION

Set up one or more teams to methodically review the steam and condensate system, identifying condensate to be returned, insulation that should be improved, steam leaks that should be repaired, and steam traps to repair or replace.

2.1 Evaluation of Condensate Return

Review all condensate users and check their condensate drain systems. Check for condensate quality and quantity; identify amounts which must be dumped due to contamination. Identify which users are connected to which intermediate condensate storage tanks. Evaluate flash steam losses at intermediate condensate stations, and check the possibility of recovering heat from the condensate systems to avoid flash steam losses. Check condensate storage tanks and return piping for leaks.

2.2 Steam Trap Testing Program

Inventory all steam traps. Begin a regular testing program using an ultrasonic test instrument, ensuring that every trap is tested on a regular basis at least twice per year. Tag or otherwise identify each malfunctioning trap and schedule its repair or replacement as soon as possible.

2.3 Review Steam Line Insulation

Review quality of insulation in the major user areas. Replace or upgrade insulation as necessary. Consider the use of specially made insulation pieces allowing easy removal and re-installation for valves and fittings. This should be looked at especially for the main steam distribution headers in the boilerhouse area.

2.4 Eliminate Steam Leaks

Identify, tag, and repair steam leaks, beginning with the most serious. Maintain an ongoing check on leaks, and repair them as soon as is possible.

3. DESCRIPTION/RATIONALE

The steam distribution system is in need of regular maintenance. Once the manpower is available, this area should be one of the priority areas for work.

4. BENEFITS

4.1 Energy Savings

Energy savings are estimated only: experience has generally shown possibilities of improvement of 1 to 5% in situations where efficiency teams are assigned to carefully review the steam and condensate distribution systems. In the case of Balkan, this quantity is estimated to be 5%, based on the fuel consumed for steam generation.

- at 5% saving of fuel oil:

7,400 t/y x 0.05 x $130/tonne = 48,100 $/y

5. IMPLEMENTATION COSTS

Implementation costs include handheld thermometer, perhaps an ultrasonic tester, as well as spares for steam traps, piping, and valves. Portable instruments may cost on the order of $2,500, while equipment and spares depend on the findings of the efficiency teams. A figure of $10,000 should easily cover the major losses. Thus, the total implementation cost is estimated at $12,500.

6. PAYBACK

The payback period for this project is 0.3 years, or 3 months.

7. SCHEDULE

This project should be implemented immediately, or as soon as the maintenance manpower is available.

8. TECHNICAL RISK AND REFERENCE

This project presents no risk in its implementation.

9. SPECIFICATION

Ultrasonic Tester

Type:	Ultrasonic detector
Physical:	Pistol-type detector/stethoscope, with minimum 4" probe, extendable to 15"

Output:	Analog meter on pistol and audible sound converter for use with earphones; 10/1 sensitivity calibration dial
Power:	9 V battery, optionally rechargeable
Accessories:	lightweight plug-in headset, carrying case; tone-generator and rubber focusing extension optional

Action A.4 -- Reduce Peak Demand

1. PROCESS AREA

Electrical system: plant electrical load

2. STATEMENT OF RECOMMENDATION

Identify all the electric equipment contributing to the electrical demand peak, as well as the approximate time of that demand peak. Based on this information, and production requirements, develop a daily schedule to operate the motors in such a way as to minimize simultaneous operation of all plant equipment.

3. DESCRIPTION/RATIONALE

Based on information for March 1991, electricity consumption at Balkan totaled 579,000 kWh, while demand was 2,100 kW. This is a very high demand relative to consumption (load factor is calculated at 0.38). This means that equipment with a very high load is operating for a very short time during the day, and implies that there is a good possibility to rearrange the operating schedule so that not all equipment is on at the same time.

Balkan has been aware of and interested in this problem, and has received a quotation from a local company for a microprocessor-based electrical demand control system. In the view of the audit team, this equipment costing almost $20,000 is not cost-effective for the plant at this time. This money can be spent with a much greater return on investment (see Actions A.1 through A.3). In many plants such as Balkan, electrical demand reduction of 5 to 10% can be obtained with simple manual rescheduling or control.

Even if Balkan would like to pursue an automated demand control system, the recommendation above is a prerequisite. Before deciding how to prioritize automatic shedding of loads, all the loads, their demand in kW, and their operating times must be known.

4. BENEFITS

4.1 Energy Savings

Energy savings are calculated assuming a potential demand reduction of approximately 5% of the total monthly demand. Since copies of the electric bills were not obtained, the cost to Balkan of the demand is not known. For calculation purposes, a typical U.S. cost of $20/kW/month is used below.

- at 5% average demand reduction:

2,100 kW x 0.05 x $20/kW/mo x 12 mo/y = 25,200 $/y

5. IMPLEMENTATION COSTS

Implementation costs for a rescheduling of operations are essentially zero.

6. PAYBACK

The payback for this measure would be immediate.

7. SCHEDULE

This measure should be implemented immediately.

8. TECHNICAL RISK AND REFERENCE

There is no technical risk involved in implementing this measure. If some of the operations are moved to a second shift, the cost of overtime paid to workers, as well as additional boiler and steam losses should be considered.