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ENERGY EFFICIENCY AUDIT REPORT
FABRIKA CEMENTA KOSJERIC
KOSJERIC, SERBIA, 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
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ENERGY & INFRASTRUCTURE DIVISION
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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.

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RCG/Hagler, Bailly, Inc. gratefully acknowledges the assistance and hospitality shown by Mr. Munitlak Ratomir, Direktor Radne Organizacije of Fabrika Cementa Kosjeric, his managers, and his staff during the on-site visit to the factory.

EXECUTIVE SUMMARY

This report presents the results from a preliminary energy audit carried out by a team of engineers from RCG/Hagler, Bailly, Inc. and TEKON Tehno-Konsalting at Fabrika Cementa Kosjeric from March 5 to March 8, 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.

A summary of the primary energy consumption at the plant based on 1990 data is given as follows:

	Energy Distribution			Cost Distribution	
	actual units	TJ	%	dinars	%
Electricity	44,710 MWh	537	31	22,639,131	24
Heavy fuel oil	28,484 tonnes	1,153	67	67,058,468	71
Diesel fuel	707,589 liters	26	2	4,353,022	5
TOTALS		1,716	100%	94,050,621	100

Based on the discussions with plant management 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.

		---------- Costs (US$)			--------- Years
Action ID	Recommendation	Equip-ment	Duties & Instln Costs	Energy Savings	Simple Pay-back
A.1	Energy monitoring/tracking	0	1,000	77,600	0.1
A.2	Install ampere recorders	11,600	7,500	44,400	0.5
A.3	Portable pyrometer for kiln	2,200	1,200	5,300	0.6
B.1	Kiln temperature sensor	9,000	10,000	26,600	0.7
B.2	Kiln O2/combustibles sensors	11,000	10,000	79,700	0.3
	TOTALS	33,800	29,500	233,600	0.3

CHAPTER 1 -- PLANT DESCRIPTION

Fabrika Cementa Kosjeric is located about 200 km from Belgrade in the town of Kosjeric. The plant first began operation in 1976 and currently employs a total of about 550 persons.

The plant itself consists of a number of major sections:

- raw material crushing
- raw material pre-mix storage
- raw material grinding
- pyroprocessing
- clinker grinding and final cement mixing
- finished product storage
- finished product packing.

Aside from the production areas, the plant also includes a number of buildings used for administrative, maintenance, workshop, and accounting purposes. In addition, one of the buildings houses the plant control room and laboratory.

Raw material mining facilities are located approximately 1 km from the factory. These facilities were not visited during the on-site visit.

1.1 Processes and Products

The plant is primarily engaged in the production of finished Portland cement from limestone, marl, and other raw materials. Total production capacity is about 550,000 tonnes of finished cement per year, although the plant actually produces approximately 400,000 to 450,000 tonnes per year (production figures are presented in the next chapter). The plant manufacturers cement using the dry process. Pyroprocessing technology is licensed from Krupps Polysius.

The factory is laid out to accommodate two processing lines, although only one processing line is installed. Financing constraints at the time of plant construction limited the size of the plant to only one line. The plant would like to add the second processing line at a future time, if financing can be obtained and

the market for cement can support the increased production. At the present time, the factory does not operate at capacity, mostly because of market considerations; actual production takes place for about 9 months per year.

The sequence of operations in the factory is as follows (refer to Exhibit 1.1 for a flow diagram of the process):

Limestone and marl are mined in factory-owned mines, located about 1 km from the main factory. The mining operations are conducted 5 days per week in two 7 hour shifts per day. Mined raw materials are trucked to the factory site, where they are reduced in size in a hammer mill. The crushed limestone and marl is then conveyed by conveyor belts to a covered pre-mix storage area, where they are mixed by alternating layers on one or more storage piles.

The mixed aggregate is further reduced in size in a ball mill prior to the pyroprocessing step. The milled aggregate is mixed with additional limestone or other additives to adjust its chemical composition.

At this point, the final mix is conveyed to the top of a four-stage suspension preheater where it is preheated (but not calcined) to about 800 °C before entering the kiln. The clinker is produced in the dry process kiln. The kiln is 60 meters long and about 4 meters in diameter (inside diameter). It is fired with mazout (heavy fuel oil) at the clinker exit end. Aggregate material flows through the kiln countercurrent to the hot combustion gases. At the clinker exit end of the kiln, a planetary clinker cooler reduces the temperature of the clinker, recovering the heat for preheating of secondary combustion air. A portion of the combustion gases exiting the kiln at the aggregate material entrance are used to preheat the raw material in the suspension preheater.

The plant has two electrostatic precipitators. As noted, a portion of the kiln combustion gases is used to preheat the kiln feed, while the balance of the gas is exhausted to the atmosphere. One of the electrostatic precipitators is installed at the top of the suspension preheater and is used to clean the combined kiln combustion gases and cooled gases exhausted from the suspension preheater. Recovered dust is sent back to the suspension preheater. The other electrostatic precipitator is installed near the clinker cooler, where it recovers fine clinker particles. During the current plant shut-down, the electrodes of both electrostatic precipitators are being replaced.

The clinker exiting the kiln is crushed in a ball mill and mixed

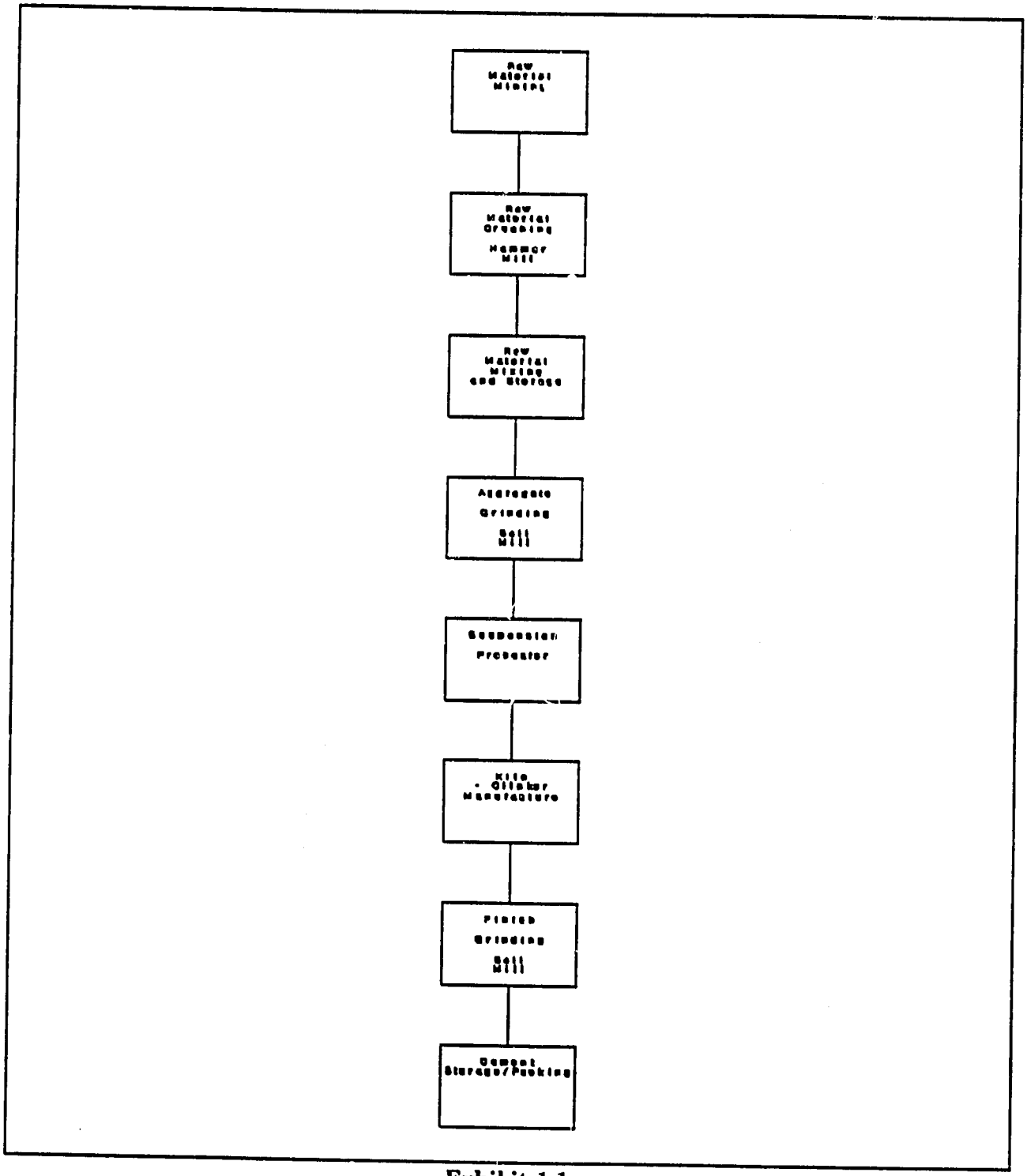


Exhibit 1.1
Cement Process Flow Diagram

with such additives as gypsum and slag to produce the final cement. The final cement consists of about 60% clinker and 40% additives. Cement is stored in a final product storage area. About one-third of the cement is bagged, while the balance is sold as bulk cement.

A secondary product produced for sale by the factory is crushed aggregate, taken directly from the hammer mill. This represents a small part of factory operations. The factory is also interested in developing a marble mining and finishing operation, but there are no firm plans for accomplishing this.

The plant produces four different types of cement for local consumption. Two of these are variations of Mark 35 cement, while the other two types are variations of Mark 45 cement. Production figures are shown in the next chapter.

1.2 Thermal Equipment

The major thermal energy consumer in the factory is the pyroprocessing department, which consists of the cement kiln and suspension preheater. The 60 meter long kiln is fired with mazout. It operates at a temperature of about 1400 °C. The kiln itself consists of a steel cylinder lined with locally produced refractory brick. The inside diameter of the kiln is 4 meters; outside diameter is about 4.4 meters. The burner is located at the clinker exit end (countercurrent flow of raw material and combustion gases). Waste heat from the hot clinker is used to preheat combustion air and secondary air. Some of the heat remaining in the combustion gases is recovered in the suspension preheater, where it is used to preheat incoming raw materials.

The kiln operates continuously on a three shift per day basis, 7 days per week. The kiln is shut down when finished product inventory levels approach storage capacity levels, for planned maintenance, or due to unexpected faults. The kiln normally operates for about 9 months per year, with operation during the winter limited due to demand for the finished product.

The kiln is controlled from a central control room located in a building across from the pyroprocessing department. The control room includes instruments for monitoring and recording critical operating variables, and controls for adjusting the operation of the entire process. In addition, hourly records of key operating variables are maintained by operations staff.

The second major area where thermal equipment is used in the factory is a small boiler plant. The boiler plant consists of two Duro Dakovic package fire-tube boilers, each rated at 3 tonnes per

hour. One boiler is normally in operation, while the other is kept as a stand-by. The boilers operate at about 7 bar pressure, although they are rated for a maximum duty of 12.5 bar.
Steam from the boilers is used primarily for fuel handling purposes. Steam coils are located in the mazout storage tanks to heat the oil to about 40 °C for pumping to the kiln fuel preparation area and boiler plant. Fuel oil pipes also consume steam through steam tracing.

Before being burned in the kiln burner, the mazout is heated to 110 to 120 °C to ensure proper atomization and complete combustion. Steam is used for this purpose in a fuel heater consisting of a steam to oil heat exchanger and associated pumps and temperature controls. Steam is also used throughout the factory for space heating during the winter months.

The third major area where thermal equipment is used is a mazout fired heater located in the clinker milling section. The burner is used to temper the material, as needed. This burner is under local manual control. An operator stationed at the burner is instructed by the central control room (via telephone) to turn the burner on or off, depending on temperature measurements received at the control room.

Diesel fuel is used for transport within the plant (e.g. loaders and other material handling equipment), between the mine and the plant and for shipping of final materials (trucks).

1.3 Electrical Equipment

Electrical equipment is used in the plant for motive power, particularly for drives used for crushing and grinding equipment. Electric motors are also used to rotate the kiln.

Electricity is received by the plant at 110,000 volts. An electrical substation located within the factory reduces voltage to 6,000 volts for distribution throughout the plant. The electrical substation consists of two 12.5 MW transformers; one transformer is on-line and the other is used as stand-by.

The major electric motors are listed below by distribution branch. A single line electrical distribution diagram is shown in Exhibit 1.2.

- raw material crushing (hammer mill) -- two motors at 280 kW
- raw material grinding mill (ball mill) -- 2,100 kW

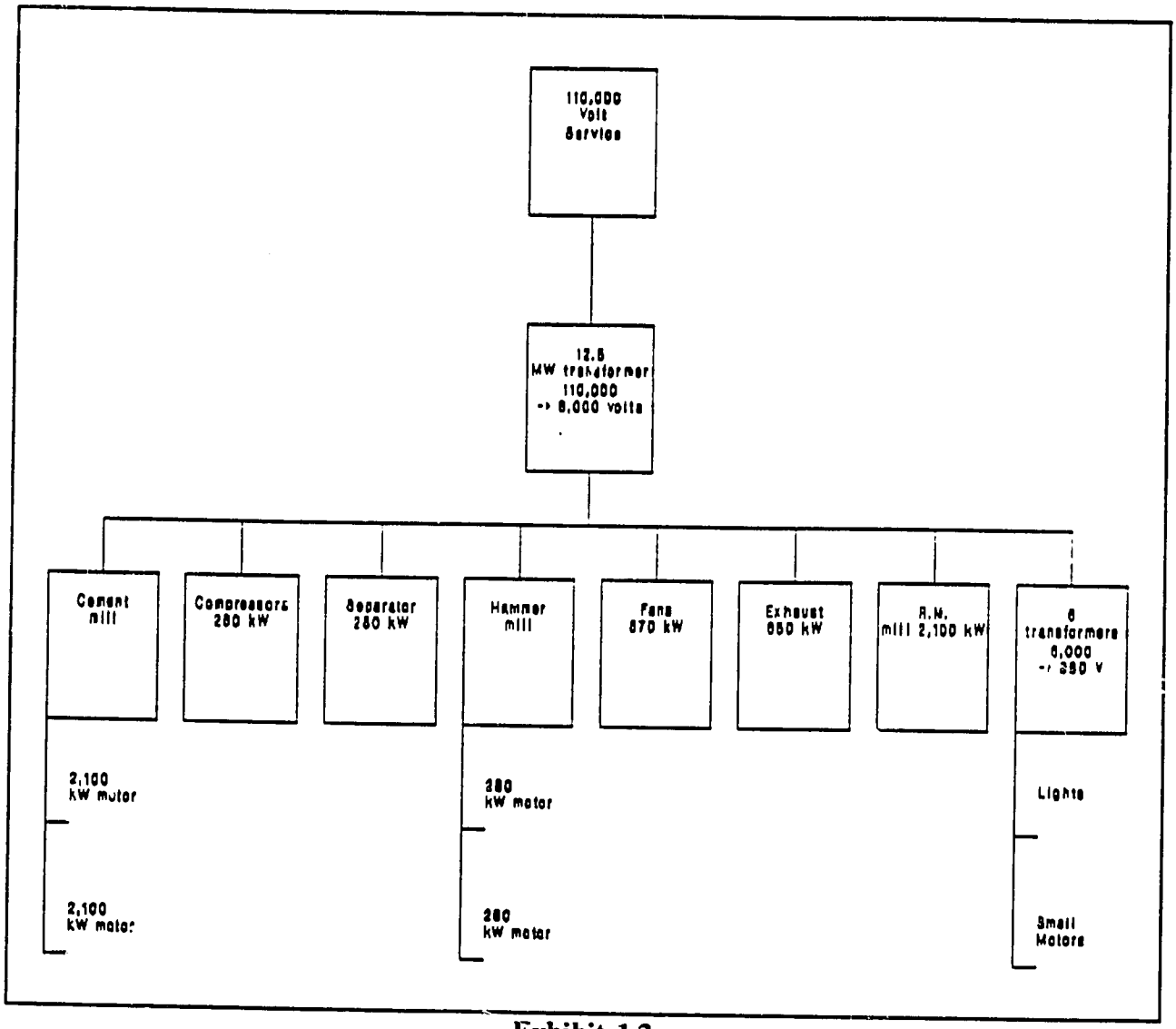


Exhibit 1.2
Electrical Distribution System

- clinker mill (final ball mill) -- two motors at 2,100 kW each
- air compressors for pneumatic blowers (for conveying materials) -- 280 kW
- kiln drive motor -- 300 kW
- separator -- 280 kW

- fans -- 570 kW
- exhaust fans -- 650 kW.

All of the above motors are operated at 6,000 volts. In addition to these large motors, there are numerous small motors throughout the factory, used for such purposes as drives for lubrication pumps and water pumps, conveyor belt systems, and other systems. Voltage is reduced to 380 volts for these systems. Electricity is also used for lighting.

Power factor for the factory is quite high. Capacitors are installed on many of the distribution branches serving large motors to ensure high power factor.

1.4 Plant Management and Staff

The management responsibility of Fabrika Cementa KOSJERIC rests on the shoulders of the General Manager, Dipl. Ing. Munitlak Ratomir. Mr. Ratomir has 5 department managers: Production, Technical, Financial, Commercial and General. In total, the Fabrika Cementa KOSJERIC has 12 Managers, 18 Foremen and 550 laborers.

The Production Department has three subdivisions, Mining, Cement and Laboratory. The Technical Department has three subdivisions, Engineering, Electric maintenance and Mechanical maintenance. The Financial Department has three subdivisions, Bookkeeping, Accounting and Analysis and Planning. The Commercial Department has three subdivisions, Supply and Stores, Sales and Dispatch and Transportation. The General Department has five subdivisions, Personnel, Canteen, Safety, Legal and Self Management.

CHAPTER 2 -- ENERGY AND PRODUCTION DATA

Energy and production data are summarized in the tables in this section, as well as in the graphs presented at the end of the report.

2.1 Purchased Electricity

Electricity is purchased from the local electricity distribution company. The electric tariff consists of three basic charges for the factory:

- Electricity consumption in kilowatt-hours: peak and off-peak tariffs apply to this factory, and the price of electricity varies during a 24 hour period. Currently, the peak consumption period is from 0700 to 1400 hours and from 1600 to 2200 hours. Additionally, summer and winter rates apply. Summer rates for 1990 are shown below:

Peak period:	0.33 dinar per kWh
Off-peak period:	0.17 dinar per kWh

  Total annual electricity consumption for 1990 was 44,710,050 kWh. For 1989, this figure was 44,706,450 kWh.

- Maximum demand measured in kilowatts: the electric utility provides a meter which record maximum demand based on the maximum consumption recorded during any 15 minute period during the month. The cost per kW per month is 138.17 dinars. During 1990, monthly peak demand ranged from a low of 440 kW (during a month when the factory was not operating) to a high of 8,920 kW. During 1989, these figures range from a low of 1,060 kW to a high of 8,730 kW.

- Power factor, measured in kilovolt-ampere-hours reactive: power factor is not metered directly, but is measured in terms of kVArh. As for the electricity consumption rates, these rates are also based on peak and off-peak consumption and summer and winter rates apply. Summer rates for 1990 are shown below:

Peak period:	0.07 dinar per kVArh
Off-peak period:	0.04 dinar per kVArh

  Total annual kVArh consumption in 1990 was 2,597,744; in 1989, this figure was 2,503,083.

	Active Electric kWh	Reactive Electric kVArh	Peak Demand kW
January '90	132,000	--	440
February	3,836,250	250,388	8,580
March	4,286,700	215,589	8,920
April	3,986,400	205,788	8,222
May	3,997,950	195,376	8,660
June	4,827,900	292,744	8,440
July	3,399,000	152,129	8,460
August	4,600,200	288,685	8,460
September	4,987,950	370,277	8,460
October	5,068,800	332,046	8,580
November	3,757,050	222,073	8,520
December	1,829,850	72,649	8,520
TOTAL	44,710,050	2,597,744	

Exhibit 2.1
Electricity Consumption for 1990

Electricity consumption for 1990 is shown in Exhibit 2.1.

Electricity consumption is monitored by operating section by plant personnel. kWh meters, located in two switchgear rooms, record consumption on several of the major distribution circuits. A report is prepared monthly by the electrical maintenance manager. This report assigns electrical costs to each operating department in the plant. Demand meters are not installed within the factory, and the contribution of individual distribution branches to maximum demand is not known.

2.2 Mazout (Heavy Fuel Oil) and Diesel

Mazout (heavy fuel oil) is purchased from the national refinery. It is delivered to the factory by rail; a rail siding is located adjacent to the factory. Mazout is consumed by the kiln, boilers, and a mazout-fired heater; only mazout consumption at the kiln is metered.

Mazout prices have increased substantially since the third quarter of 1990, as shown in Exhibit 2.2. Despite the decrease in world

Date -->	July 1990	August 1990	September 1990	March 1991
Base Price	1,898	1,898	2,179	3,068
Transport	90	118	135	159
Demurrage	10	12	14	14
Tanker Rental	118	133	133	160
TOTAL COST PER TONNE (Dinars)	2,116	2,161	2,461	3,401

Exhibit 2.2
Mazout Prices

oil prices, local prices have not decreased.

Date -->	July 1990	August 1990	September 1990	March 1991
Price per Liter (Dinar)	6.10	6.10	7.20	8.50

Exhibit 2.3
Diesel Prices

Trends in diesel prices over the same period are shown in Exhibit 2.3.

Monthly consumption of mazout and diesel are shown in Exhibit 2.4.

	Mazout tonnes	Diesel liters
January '90	70	21,565
February	2,090	40,237
March	2,843	66,043
April	2,750	73,169
May	2,435	68,874
June	3,080	67,993
July	1,849.2	71,208
August	2,415.6	75,761
September	3,394	68,042
October	3,321.8	87,151
November	3,091.8	45,737
December	1,143.5	21,809
TOTAL	28,484.0	707,589

Exhibit 2.4
Monthly Mazout and Diesel Consumption

2.3 Other Fuels

Small amounts of bottled gas (butane) are consumed in the factory for cooking and laboratory use. This consumption is considered to be negligible and is not included in the totals presented below.

2.4 Production

Production figures by type of product produced in 1990 are shown in Exhibit 2.5.

2.5 Analysis of Historical Energy and Production Data

As in most industrial plants, there is a large amount of energy and production data available at Kosjeric. However, this data is not always used to its maximum extent. A small amount of this data was made available to the audit team; this data was presented in tabular form in the previous sections, and is presented in various graphs at the end of this report.

The first two graphs show the variation in monthly consumption throughout the year of fuel oil and electricity, respectively.

	PC 30 DP 35 S		PC 30 DZ 45 S		PC 15 z 45 B	NPC 30 z 35	TOTAL
	Packed	Bulk	Packed	Bulk	Bulk	Bulk	
January '90	3,602	2,286	1,639	1,713	4,217	170	13,627
February	8,773	1,742	---	9,794	7,862	637	28,808
March	14,335	2,295	---	12,477	8,170	826	38,103
April	12,044	1,765	---	13,626	6,903	605	34,943
May	19,296	3,120	---	16,123	8,856	1,383	48,778
June	17,607	3,836	---	13,508	7,400	2,202	44,553
July	17,177	4,152	---	12,782	6,477	1,461	42,049
August	24,524	7,100	---	15,369	7,490	935	55,418
September	22,708	6,015	---	15,302	8,566	688	54,279
October	19,353	4,669	---	19,636	10,471	377	54,506
November	5,872	2,328	---	14,170	7,003	250	29,623
December	1,146	552	---	6,241	5,457	220	13,616
TOTAL	166,437	39,860	1,639	151,741	88,872	9,754	458,303

Exhibit 2.5
Monthly Production by Product Type for 1990
(tonnes)

They both show a very low consumption in the first and last months of the year, a dip in the middle of the year, and peaks in the spring and fall, with fall slightly higher. Looking at the third graph "1990 Cement Production" the variation throughout the year is approximately the same; however, the month of August represents the highest production, even though the energy consumption is lower, and November has high energy consumption for a low production. The comparison of these three graphs gives an idea of the trends of production and energy consumption, but it is hardly enough for a detailed analysis of energy efficiency.

The next level of detail is presented in the fourth graph, "Energy vs. Production -- 1990"; the monthly sum of both electric and thermal energy is plotted against the production. Here, as expected, as production increases, energy consumption increases. However, there appear to be wide variations in the increase. When a regression line is drawn to approximate the trend in the data, the months of May, July, and August have lower energy consumption than the trend, while other months, especially November, are significantly higher.

Since energy consumption relative to production is of interest, and since it varies with the level of production, a better way to

express the same relations is given in the fifth graph "Specific Energy Consumption -- 1990". Such a graph, along with its regression line, can be used as a basis for monthly comparisons of energy efficiency. The regression line shows how the specific energy consumption (SEC) varies with production; deviations from this variation (November, for example) can immediately be spotted.

To provide a still better understanding, separate specific energy consumption (SEC) rations should be determined for thermal and electrical energy. This is shown in the sixth and last graph "Specific Electricity and Mazout Consumption". Such a comparison can help provide important answers to why the SEC varies. For example, for most of the months, the relative SECs for electric and thermal energy seem to agree. Exceptions are February (electric SEC higher than the trend, while thermal SEC is lower) and November (thermal SEC significantly higher than electric SEC relative to the trends).

Careful analysis of curves such as these can provide good insight into efficiency trends and problems at the plant, and it is recommended that such graphical comparisons be practiced regularly. Additional observations about these analyses include:

- Examples of the types of questions that should be asked looking at the last graph are: why was the SEC so much lower than for most other months, especially June, which had similar production? If it could be done for July, why couldn't it be done for all the other months? Was anything different about July, for example, operating parameters, type and quality of product, even ambient temperature?

- Data shown here were only for one year; once data is taken for several years, a much better statistical trend can be established.

- Still better, if possible, daily production and consumption data should be recorded; these data should be plotted on a weekly or monthly basis to evaluate the efficiency and identify reasons for daily deviations from the average trends.

- The second graph "1990 Electric Demand and Consumption" shows that regardless of variation of consumption, electrical demand remains fairly constant. This implies that production should be maxinized on a monthly basis to minimize the cost effects of the demand. Also, as recommended in Action A.2 which follows, electrical

consumption should be monitored to identify possible reductions in consumptions, as well as in peak demand.

CHAPTER 3 -- ENERGY CONSERVATION RECOMMENDATIONS

The cement factory at Kosjeric is in generally very good condition. The company has established and maintained an extremely high level of maintenance, including a preventive maintenance system. Although the actual operation of the factory was not observed during the on-site visit, examination of operating logs and discussions with plant personnel indicated that existing instrumentation is in generally good operating condition. Nevertheless, during the audit, RCG/Hagler, Bailly, working with plant management and technical staff, was able to identify a number of actions to save energy.

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 prodution. These actions are usually simple, often imply very little cost, and should be implemented as rapidly as possible. Actions which fall in this category are coded by "A" preceeding the list number. Fabrika Cementa Kosjeric 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. These are also actions in which USAID might be able to participate under this program. Actions of this category are indicated with a "B" preceeding 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.

In the case of Fabrika Cementa Kosjeric, no actions were identifed in the "C" category. However, a longer, more detailed energy audit, which would concentrate more deeply on the process, could be expected to yield 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 required)
- Back-up data and calculations, as necessary.

ACTION A.1 - Improve Energy Monitoring and Tracking

1. PROCESS AREA

Energy management; affects overall plant energy consumption and production

2. STATEMENT OF RECOMMENDATION

Collect, monitor and analyze plant energy consumption and production data on a daily basis. The same data currently collected and analyzed on a monthly basis should be included. Shift supervisors from each of the major energy producing and consuming areas of the plant should report specific energy consumption figures (i.e. tons of cement per ton of mazout or tons of clinker per kWhr). These data should be compared on a daily basis and included as part of the daily report to the General Director of the plant. In turn, these results, and any particular changes they require, should be documented and fed back to operating personnel.

On a monthly basis, plot the variations of specific energy consumption with production, to evaluate the overall trends in plant efficiency.

To assist plant management in this measure, it is recommended that this data be entered daily into the existing computer system at the factory. This will allow easy manipulation of the data, as well as storage of data with easy retrieval for future analysis.

3. DESCRIPTION/RATIONALE

Fabrika Cementa KOSJERIC currently monitors and records on a monthly basis most of the important energy consumption and conversion parameters vital to the efficient operation of the plant. This includes overall mazout consumption, steam production, overall electrical energy consumption, and the consumption of electrical energy and steam by various sub-areas of the plant. Likewise, production figures for various portions of the plant, and in some cases for individual machines are currently collected and reported on a monthly basis.

Tracking energy usage is the first and most crucial step in establishing an effective energy management program. Without proper monitoring of consumption, it is impossible to prioritize potential energy conservation projects or to measure their

effectiveness once they are implemented. Daily tracking provides immediate feedback for the evaluation of changes in operating practices or warning of equipment degradation or failure. Since the control of some of the major energy consuming equipment such as the boilers is done on a largely manual basis, it is important to provide timely feedback to operators as a means of helping them to control the equipment most efficiently. Boiler operating efficiency is not currently measured, so operators have no basis for improving their performance from an efficiency standpoint.

Secondly, a detailed monitoring program can provide warnings as to the degradation or failure of important equipment. For example, a sudden jump in the specific mazout consumption for the kiln might signal a burner operating problem, or poor adjustment of the combustion air. If the consumption data are averaged over an entire month, the failure would be more difficult to spot and a great deal of energy could be wasted before corrective action was taken.

Finally, a thorough energy monitoring program will increase the awareness of both supervisory and operating personnel to the importance of energy conservation, resulting in cooperation and perhaps contribution of ideas to assist the program. Workers at all levels must be enlisted as partners for energy conservation programs to work effectively.

4. BENEFITS

4.1 Energy Cost Savings

While the savings from energy management cannot be calculated exactly, such programs commonly provide 1 to 5% savings of overall energy consumption. This savings comes about from both better monitoring, as well as from more conscientious operation of the equipment by the operating staff, who know that performance is being constantly evaluated. Total annual energy savings at 1% improvement is estimated at $ 77,600.

- mazout energy savings (1% improvement):

1/100 x 28,500 t/y x 4100 din/t x 1/22 $/din = 53,200 $/y.

- electrical energy savings (1% improvement):

1/100 x 44,710,000 kWh/y x 1.2 din/kWh x 1/22 $/din = 24,400 $/y

5. IMPLEMENTATION COSTS

Costs of implementing this recommendation are estimated at $ 1000. These costs include the purchase of some spreadsheet software, and the training of one or two staff persons to use this software. The computer is already available at the plant.

6. PAYBACK

The payback period for this recommendation is approximately 0.2 months.

7. SCHEDULE

This action should be implemented immediately by the management of the factory.

8. TECHNICAL RISK AND REFERENCE

not applicable

9. SPECIFICATION OF EQUIPMENT

not applicable

ACTION A.2 - Install Recording Ammeters to Monitor Plant Electrical Demand

1. PROCESS AREA

Electricity demand management: recording ammeters to be installed at electric control centers to record amperage of various plant distribution circuits as an analog to electric demand.

2. STATEMENT OF RECOMMENDATION

2.1 Electric Demand Management Program

Use three recording ammeters to record amperage of major distribution circuits in the plant as an analog to peak demand. Use the records of demand to determine contribution to peak electric demand of each major processing department (on individual distribution circuits). Use the results of the analysis to formulate strategies to reduce peak coincident demand, particularly on plant start-up.

3. DESCRIPTION/RATIONALE

Discussions with the electrical maintenance manager revealed that peak billing demand for the factory is most probably established during plant start-up, when a number of large electric motors are all started at or near the same time. Existing instruments do not have the capability of recording amperages for each distribution circuit; hence the contribution of each plant processing area to the total peak demand is not known. Recording ammeters used in conjunction with installed instrumentation will allow the development of load profiles for each major process area in the factory and the development of strategies for controlled manual start-up of equipment to minimize peak electric billing demand.

4. BENEFITS

4.1 Demand Cost Savings

This demand management project will not result in energy savings, but rather in a reduced peak billing demand, and the demand charges associated with it.

In 1990, peak demand ranged from 440 kW (in a month when there was very little production) to 8920 kW (during a month of moderate production). Demand charges are currently 138.17 dinars per kW per

month. For 1990, total demand charges amounted to approximately 13 million dinars or $592,000 (at 22 dinars to the U.S. dollar).

Peak billing demand can probably be reduced by 5 to 10 percent through a demand management program. Assuming a 7.5 percent reduction, the annual demand charge savings to the factory would be $44,400.

5. IMPLEMENTATION COSTS

The installed cost of the systems is estimated at $ 19,100.

	Cost of Equipment (USAID project)	Duties, taxes, install'n (plant)	TOTAL COSTS
Six-channel strip chart recorder (2)	$ 8,000	$ 5,000	$ 13,000
Two-channel strip chart recorder (1)	2,000	1,500	3,500
DC current transducers (16)	1,600	1,000	2,600
TOTAL	11,600	7,500	19,100

6. PAYBACK

The payback period for the purchase of these instruments is approximately 5 months.

7. SCHEDULE

Task 1 -- completion date: June 15, 1991

HBI prepares and addresses to Kosjeric the specifications for instruments. HBI gets quotations from US manufacturers.

Task 2 -- completion date: June 30, 1991

Kosjeric reviews specifications and makes recommendations for selection of supplier.

Task 3 -- completion date: July 5, 1991

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

Task 4 -- completion date: August 20, 1991

Shipment of equipment arrives in Yugoslavia. Kosjeric prepares a workplan for installation and startup of the system. Kosjeric develops format for data collection and review.

Task 5 -- completion date: August 31, 1991

Kosjeric presents results of the measurements using the new recording systems, and begins to evaluate possible adjustments in operating conditions based on the measured values.

Task 6 -- completion date: September 10, 1991

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

8. TECHNICAL RISK AND REFERENCE

Proper installation and operation of the instruments presents no risk to the company.

9. SPECIFICATION OF EQUIPMENT

Type:	Electronic strip chart recorder, 2-channel (1 required) and 6-channel input (2 required)
Physical:	Panel mountable, with front cover access to chart
Input:	Direct input of 100 vdc signal at either 0 to 1 or 0 to 5 amperes dc, scalable by programming of the recorder; alternate mA input by use of dc current transducer on existing instrument feeds
Output:	Multi-color pen or dot matrix print-out of amperage, one color per channel Adjustable/programmable paper speed and sampling rate
Power:	input 220V 50Hz
Accessories:	detailed instruction and operation manual
Spares:	30 rolls printer paper 10 spare pens for each color or 6 spare multi-color dot matrix printer ribbons

ACTION A.3 - Use a Portable Pyrometer to Monitor Kiln Outside Temperature

1. PROCESS AREA

Cement kiln: cement sintering process

2. STATEMENT OF RECOMMENDATION

Use an infrared pyrometer to monitor the operating skin temperature of the clinker kiln. Perform a complete scan of the surface temperature several times a month. Write down temperatures at specific locations for later reference.

3. DESCRIPTION/RATIONALE

The kiln represents the major energy consumer at Fabrika Cementa Kosjeric. While kiln losses are part of the normal operation of the kiln, these losses should be kept to a minimum. The identification of hot spots on the kiln surface by remote temperature measurement can identify potential problems in the inside refractory before they lead to large energy losses, and more importantly, cause significant down time due to the need for unscheduled maintenance.

4. BENEFITS

4.1 Energy Savings

Energy savings are based on annual fuel consumption for the kiln of 28,500 tonnes of No. 6 oil (mazout). While potential energy savings depend on the condition of the kiln refractory, and the method of operation, these savings are conservatively estimated at 0.1 % of the average annual energy consumption of the kiln.

- kiln outside surface temperature monitoring: 0.1% savings

0.1/100 x 28,500 t/y x 4100 din/t x 1/22 $/din = 5,300 $/y.

5. IMPLEMENTATION COSTS

The total cost of a portable infrared pyrometer is estimated at $ 3,400.

	Cost of Equipment (USAID project)	Duties, taxes, install'n (plant)	TOTAL COSTS
Hand-held infrared pyrometer	$ 2,200	$ 1,200	$ 3,400

6. PAYBACK

The overall payback period is approximately 0.6 years, or 7 months.

7. SCHEDULE

Task 1 -- completion date: June 15, 1991

HBI prepares and addresses to Kosjeric the specifications for the instruments. HBI gets quotations from US manufacturers.

Task 2 -- completion date: June 30, 1991

Kosjeric reviews specifications and makes recommendations for selection of supplier.

Task 3 -- completion date: July 5, 1991

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

Task 4 -- completion date: August 20, 1991

Shipment of equipment arrives in Yugoslavia. Kosjeric prepares a workplan for installation and startup of the system. Kosjeric develops new format for data collection in the process control room to include kiln temperature, O2 and CO measurement logging, as well as a brief training program for process operators to work with the new system.

Task 5 -- completion date: August 31, 1991

Kosjeric presents results of initial operation tests using the new measurement systems, and results of any adjustments in operating conditions based on the measured values.

Task 6 -- completion date: September 10, 1991

HBI reviews Kosjeric 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 6, 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

Pyrometer application:

- Instrument will be used in the electric power generation industry
- Hand held infrared pyrometer with sighting scope and carrying case
- Temperature range: -30 deg C to 1,400 deg C (some flexibility)
- Non-contact, solid surface temperature measurement
- Require equipment to be made in the U.S.A.
- Closest distance to focal point estimated at 6-10 feet
- Typical target size beyond focal point is estimated at "D"/50

ACTION B.1 - Install Kiln Temperature Sensors for Improved Process Temperature Control

1. PROCESS AREA

Cement kiln: cement sintering process

2. STATEMENT OF RECOMMENDATION

Improve the control of the high temperature sintering process by monitoring process temperature. Adjust burner firing rate to maintain temperature at consistent level. The temperature should be the lowest temperature that yields sufficient product quality at the normal production rate. Install the following:

-- infrared pyrometer with local sensing and remote temperature readout

Train the operators to base their manual adjustments of the process conditions on the readings given by the temperature and O2 readout. Institute regular logging of combustion zone temperature, O2 and CO on the control room data sheets.

3. DESCRIPTION/RATIONALE

Fabrika Cementa Kosjeric currently has no kiln combustion area temperature sensing or reliable/operable kiln outlet O_2 and CO sensors. Combustion and temperature control are manual and are based on visual inspection of flame and kiln outlet temperature.

Both clinker temperature and excess air have an effect on fuel consumption. Although these effects are small, the annual cost savings can be significant due to the large fuel consumption in a cement kiln. For example, a temperature variation of 50 C can result in a 1% difference in energy consumption.

4. BENEFITS

4.1 Energy Savings

Energy savings are based on annual fuel consumption for the kiln of 28,500 tonnes of No. 6 oil (mazout). Total energy savings are estimated at $ 26,000 below.

- kiln temperature measurement (20-25 C average improvement): 0.5% savings

0.5/100 x 28,500 t/y x 4100 din/t x 1/22 $/din = 26,600 $/y.

5. IMPLEMENTATION COSTS

The installed cost of the system is estimated at $ 19,000.

	Cost of Equipment (USAID project)	Duties, taxes, install'n (plant)	TOTAL COSTS
Optical temperature sensing and readout system	$ 9,000	$ 10,000	$ 19,000

6. PAYBACK

The overall payback period is approximately 0.7 years, or 9 months.

7. SCHEDULE

Task 1 -- completion date: June 15, 1991

HBI prepares and addresses to Kosjeric the specifications for the instruments. HBI gets quotations from US manufacturers.

Task 2 -- completion date: June 30, 1991

Kosjeric reviews specifications and makes recommendations for selection of supplier.

Task 3 -- completion date: July 5, 1991

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

Task 4 -- completion date: August 20, 1991

Shipment of equipment arrives in Yugoslavia. Kosjeric prepares a workplan for installation and startup of the system. Kosjeric develops new format for data collection in the process control room to include kiln temperature, O2 and CO measurement logging, as well as a brief training program for process operators to work with the new system.

Task 5 -- completion date: August 31, 1991

Kosjeric presents results of initial operation tests using the new measurement systems, and results of any adjustments in operating conditions based on the measured values.

Task 6 -- completion date: September 10, 1991

HBI reviews Kosjeric 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 6, 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

Reference: KOS-T

General Description: An infrared pyrometer is needed to measure the temperature of clinker inside a cement kiln.

Physical:
Mounted on air-cooled kiln door
Material to be measured is 26m from the kiln door
Cooling must be provided for the sensor
Remote display in control room
Ambient temperature conditions: -5 to 60 C
500 ft to control room

Input Conditions:
Clinker material at 1400 C
Sampling wavelength to be 0.95 to 1.05 microns
Extreme dusty environment

Output Required:
Temperature 1000-1400 C
Display and strip chart recorder

Power: 220V 50Hz

Spares: to be specified by the bidder for at least 2 years of continuous operation

Note: All equipment to be of U.S. manufacture in accordance with U.S. Government Federal Acquisition Regulations (FAR).

Please include with your bid:

Best price, delivery, terms of payment, warranties, and installation/training requirements in Yugoslavia

List of cement plant users of similar equipment, with telephone # and name of contact.

ACTION B.2 - Install O2/Combustible Sensors for Kiln Combustion Control

1. PROCESS AREA

Cement kiln: cement sintering process

2. STATEMENT OF RECOMMENDATION

Improve the control of the high temperature sintering process by monitoring, in addition to the process temperature, the exhaust oxygen (O2) concentration, and exhaust carbon monoxide (CO) concentration. Maintain oxygen concentration at the minimum level which does not cause excessive combustibles. Install the following instruments:

-- O2 and CO/combustibles sensors at the exhaust gas outlet, with remote readout.

Train the operators to base their manual adjustments of the process conditions on the readings given by the temperature and O2 readout. Institute regular logging of combustion zone temperature, O2 and CO on the control room data sheets.

3. DESCRIPTION/RATIONALE

Fabrika Cementa Kosjeric currently has no reliable/operable kiln outlet O_2, CO, or combustibles sensors. Combustion and temperature control are manual and are based on visual inspection of flame and kiln outlet temperature.

Excess air has a direct effect on fuel consumption. Although this effect is small, the annual cost savings can be significant due to the large fuel consumption in a cement kiln. High excess air levels can affect the combustion efficiency and fuel consumption by up to 3% or more, depending on the existing condition.

4. BENEFITS

4.1 Energy Savings

Energy savings are based on annual fuel consumption for the kiln of 28,500 tonnes of No. 6 oil (mazout). Total energy savings are based on an average annual 1.5% decrease in fuel consumption due to improvement in combustion efficiency.

- kiln excess air reduction: 1.5% average savings over the year

1.5/100 x 28,500 t/y x 4100 din/t x 1/22 $/din = 79,700 $/y

5. IMPLEMENTATION COSTS

The installed cost of the systems is estimated at $ 21,000.

	Cost of Equipment (USAID project)	Duties, taxes, install'n (plant)	TOTAL COSTS
O2/CO-combustibles sensors and readout system	$ 11,000	$ 10,000	$ 21,000

6. PAYBACK

The overall payback period is approximately 0.3 years, or 3 months.

7. SCHEDULE

Task 1 -- completion date: June 15, 1991

HBI prepares and addresses to Kosjeric the specifications for the instruments. HBI gets quotations from US manufacturers.

Task 2 -- completion date: June 30, 1991

Kosjeric reviews specifications and makes recommendations for selection of supplier.

Task 3 -- completion date: July 5, 1991

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

Task 4 -- completion date: August 20, 1991

Shipment of equipment arrives in Yugoslavia. Kosjeric prepares a workplan for installation and startup of the system. Kosjeric

develops new format for data collection in the process control room to include kiln temperature, O2 and CO measurement logging, as well as a brief training program for process operators to work with the new system.

Task 5 -- completion date: August 31, 1991

Kosjeric presents results of initial operation tests using the new measurement systems, and results of any adjustments in operating conditions based on the measured values.

Task 6 -- completion date: September 10, 1991

IBI reviews Kosjeric 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 6, 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

Reference: KOS-1

General Description: An O_2/combustibles gas analysis system is required in the gases exiting a cement kiln in Yugoslavia. This high particulate environment will require a convection or diffusion type of sensing/analysis system.

Physical:
Stack-mounted sampling system
Stack approximate dimensions (5 ft x 12 ft)
Local board with sample conditioning/analysis system, weatherproof
O_2 and CO/combustibles remote display in control room
Ambient temperature conditions: -5 to 60 C
30 ft from sampling probe to local board
500 ft to control room

Input Conditions: Exhaust gases, stack temperature max 900 C, nominal 600 C
Fuel: No. 6 fuel oil, maximum 3% sulfur

	Stack draft: +/- 10 inches H2O
Output Required:	02: 0-10% Combustibles: 0-5000 ppm Strip chart recorders, both O_2 and combustibles Adjustable alarms for oxygen and combustibles
Power:	220V 50Hz
Accessories:	Manual calibration port
Spares:	to be specified by the bidder for at least 2 years of continuous operation
Note:	All equipment to be of U.S. manufacture in accordance with U.S. Government Federal Acquisition Regulations (FAR).

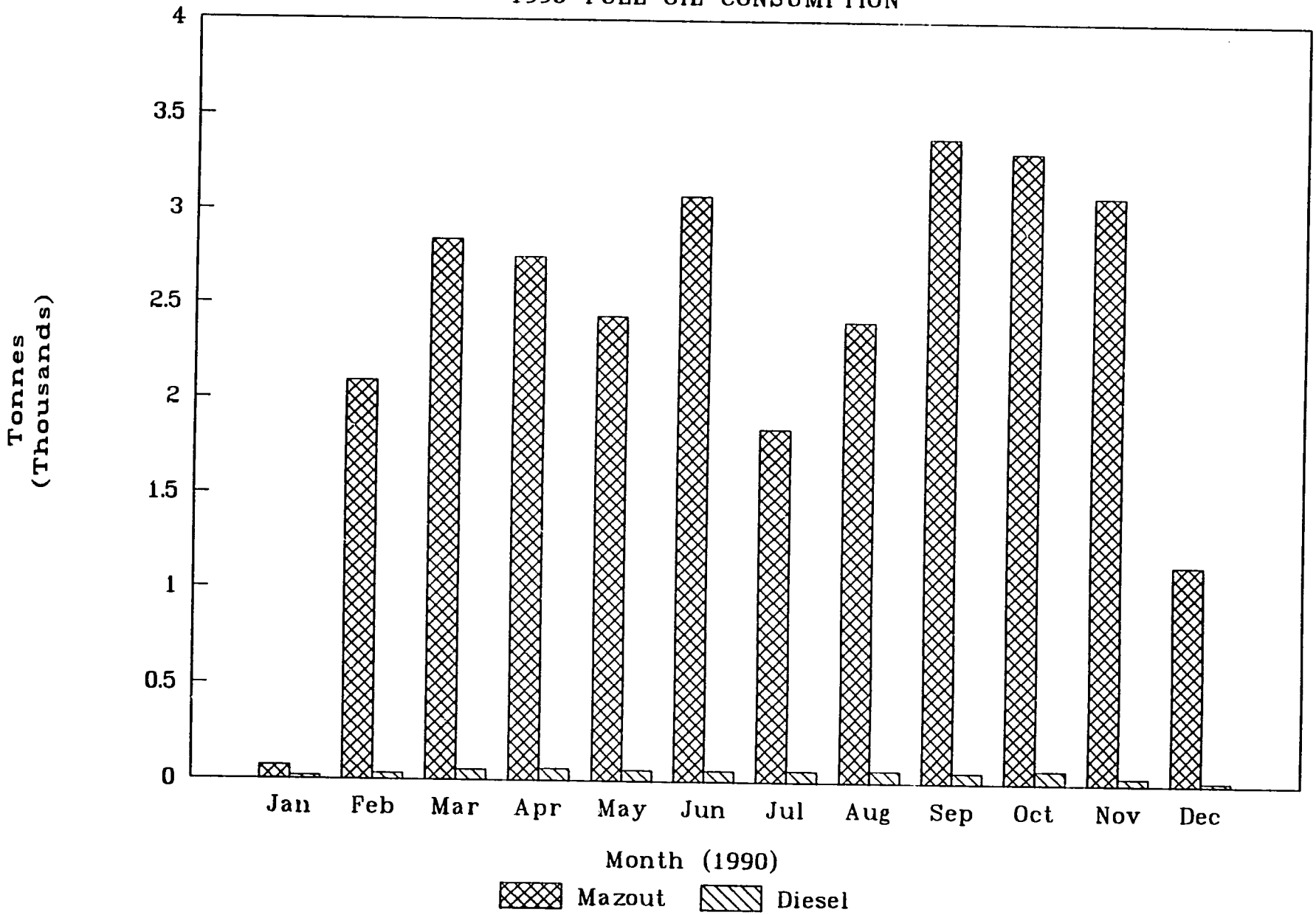
APPENDIX 1

GRAPHICAL PRESENTATION OF HISTORICAL ENERGY EFFICIENCY AND CONSUMPTION DATA

FABRIKA CEMENTA KOSJERIC

FABRIKA CEMENTA KOSJERIC

1990 FUEL OIL CONSUMPTION



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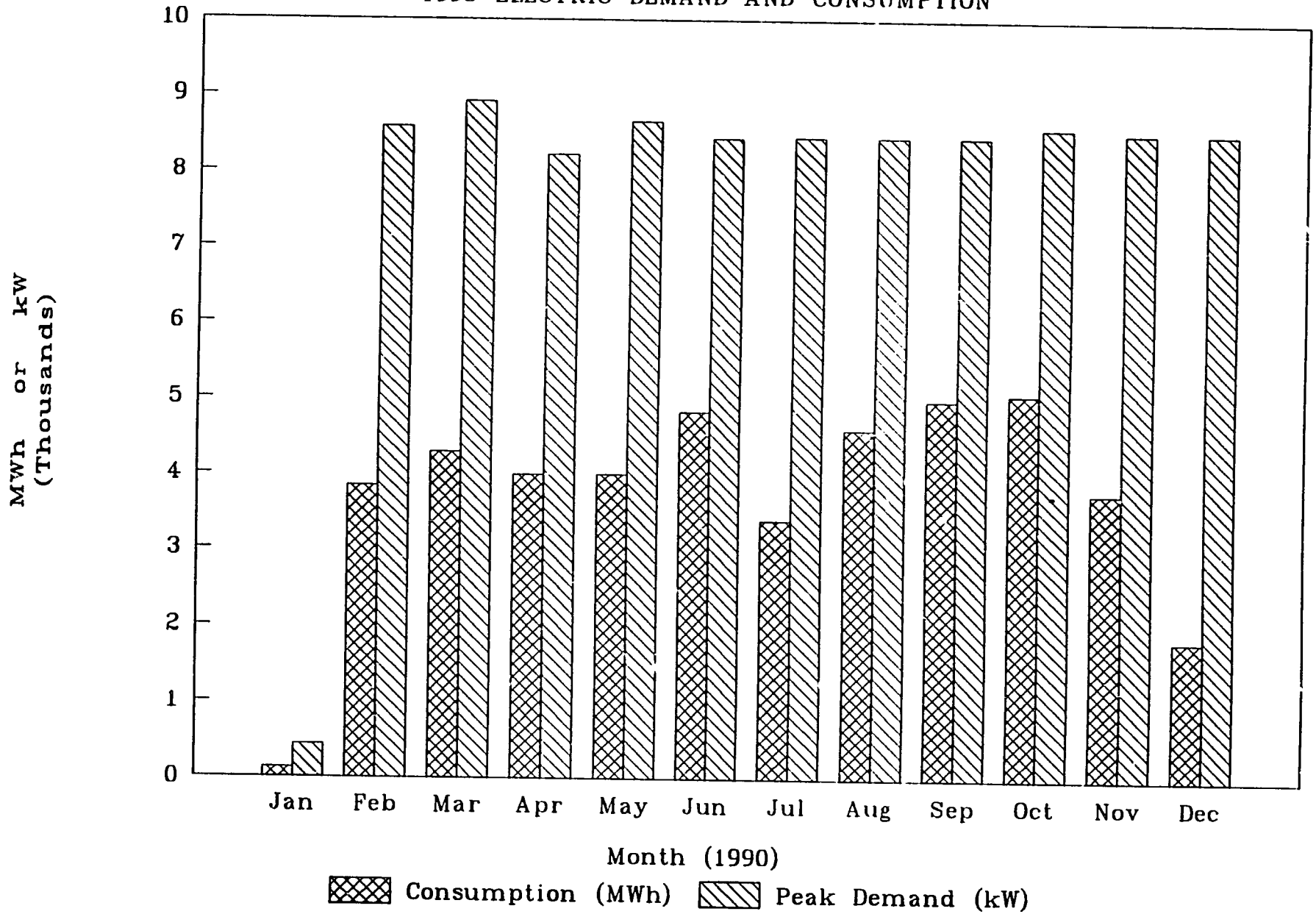
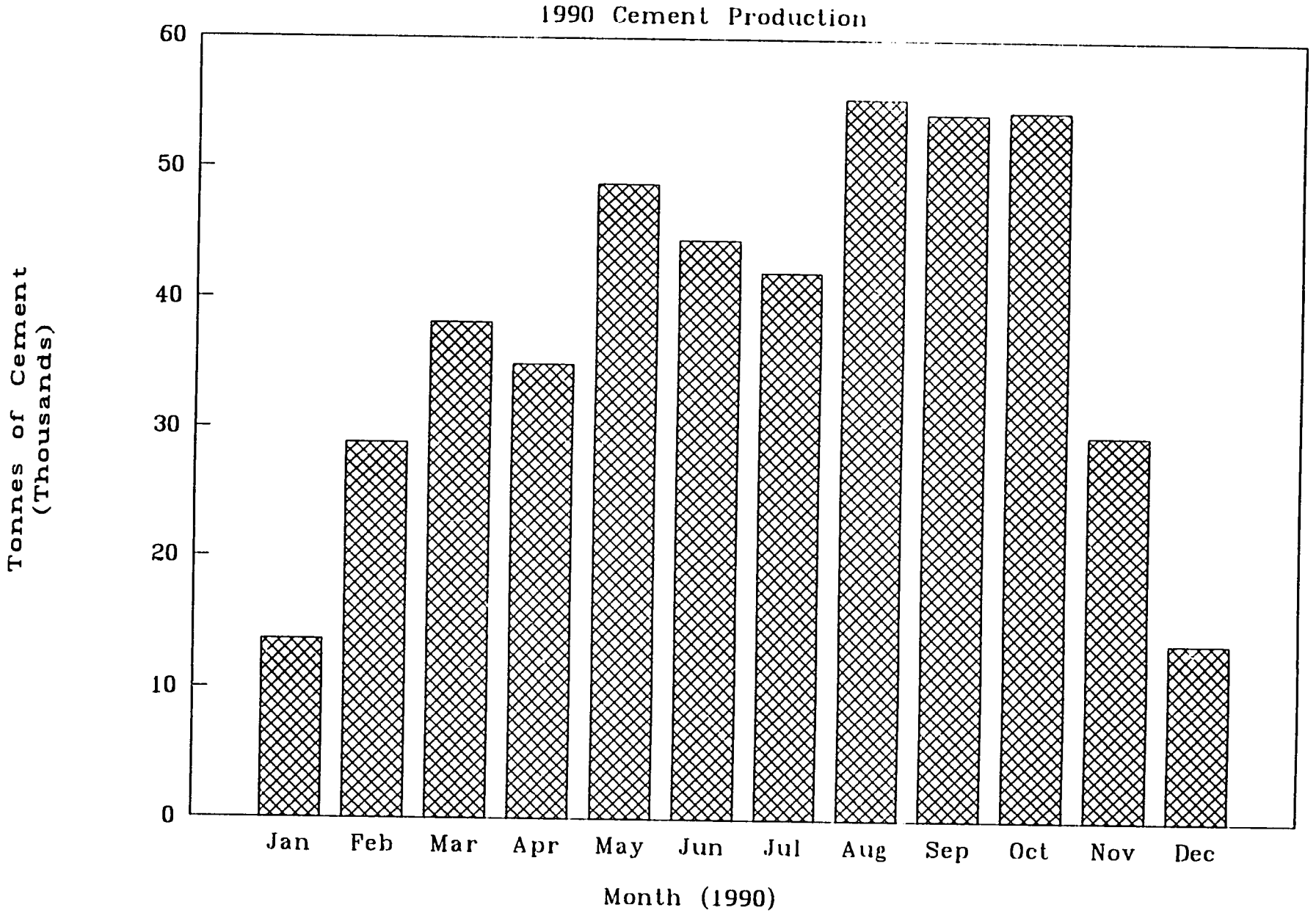
FABRIKA CEMENTA KOSJERIC

1990 ELECTRIC DEMAND AND CONSUMPTION

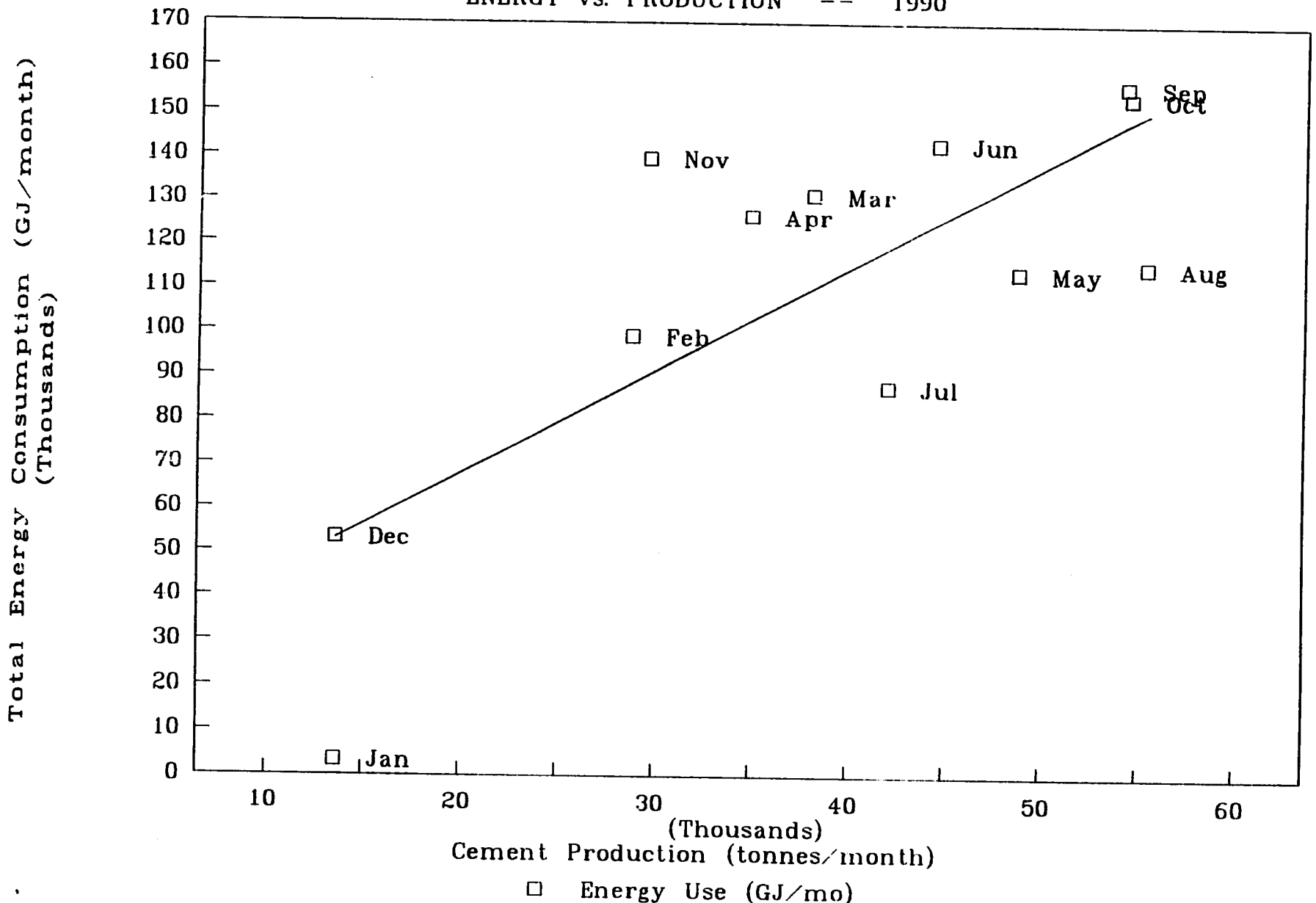


FABRIKA CEMENTA KOSJERIC



FABRIKA CEMENTA KOSJERIC

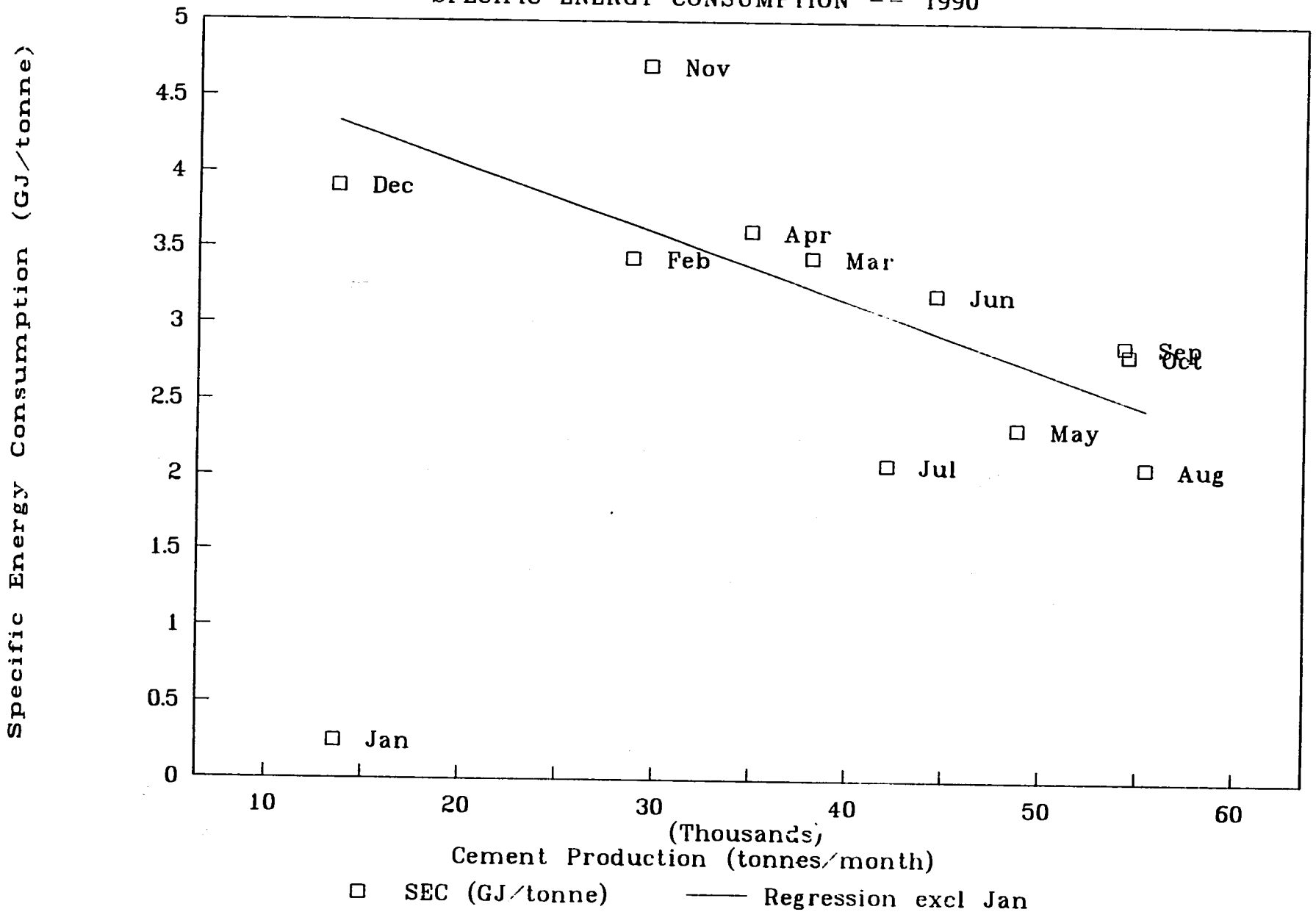
ENERGY vs. PRODUCTION -- 1990



28.

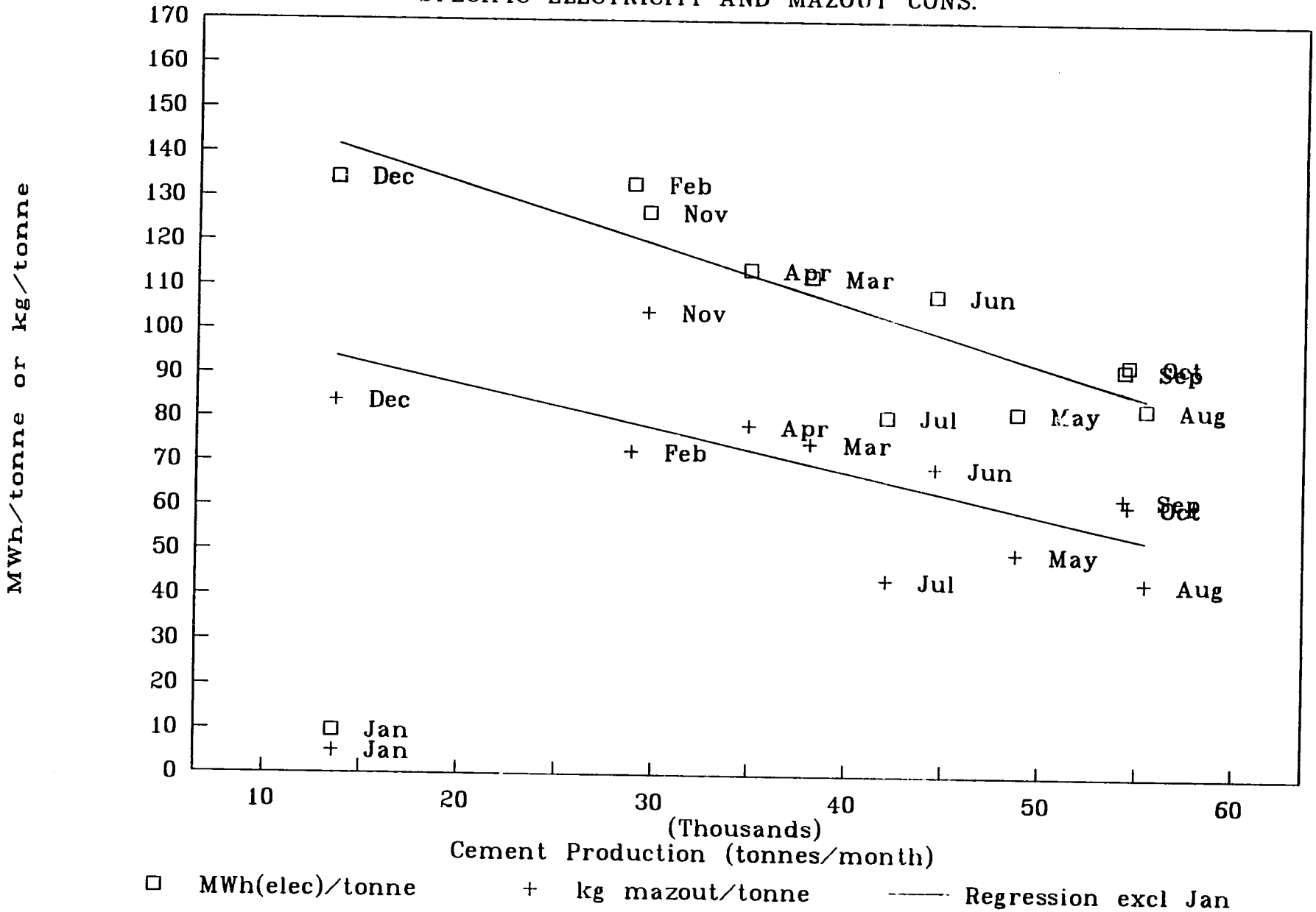
FABRIKA CEMENTA KOSJERIC

SPECIFIC ENERGY CONSUMPTION -- 1990



FABRIKA CEMENTA KOSJERIC

SPECIFIC ELECTRICITY AND MAZOUT CONS.



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