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ENERGY EFFICIENCY AUDIT REPORT
CEMENT PLANT WIERZBICA

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LIST OF ACRONYMS/ABBREVIATIONS

A.I.D.	U.S. Agency for International Development
Btu	Brish thermal unit
°C	degrees Celsius
ESP	electrostatic precipitators
IRG	International Resources Group, Ltd.
Kcal	kilo-calorie
kg	kilogram
kj	kilo-joule
kV	kilovolt
kWh	kilowatt hours
MT	metric tons
ppm	parts per million
zł	zloty; Polish unit of currency - at the time of audit, 9,400 zł = US$1

ACKNOWLEDGEMENTS

The IRG Industry Energy Audit Team for Poland wishes to express sincere thanks to the plant management and technical personnel for the valuable time and effort spent in preparing for the audit visit to the plant. The cooperation shown by the plant facilitated the communication and exchange of ideas and experiences in the area of energy management. IRG also would like to thank the U.S. Agency for International Development, European Development Resources, Office of Energy and Infrastructure for coordinating the entire project.

It is the hope of the Audit Team that the exchange established through this initiative be maintained in the future.

PREFACE

In the wake of the political and economic collapse of the Soviet Union, the nations of Central and Eastern Europe confront an energy situation for which there is no historical precedent. Overnight long-standing supply agreements for oil, natural gas and electricity supplies from the Soviet Union have been curtailed or discarded with attendant dramatic increases in the prices of these commodities. In addition, as the veil of secrecy has been lifted in these nations, the devastating legacy of years of neglect of coal and other fossil fuel pollution and an aging, largely unsafe, and unregulated nuclear power industry are vital issues that need to be addressed in light of the fundamental structural reform of these Central and Eastern European economies. Democracy for these countries means change amidst great political and economic uncertainly.

To support the transition from Soviet-based dependence to democracy, based on free market principles, the United States, in 1989, instituted a program to assist the countries of Central and Eastern Europe with humanitarian aid, technical assistance and direct economic aid. The U.S. focused initially on Poland and Hungary, where this transition was in its most advanced stages. Since that initial commitment to Poland and Hungary, the U.S. has expanded its focus to include Czechoslovakia, Bulgaria, Romania and Yugoslavia as technical assistance recipients in Eastern and Central Europe. In the future, large scale assistance is likely to be given to the Baltic States, Estonia, Latvia and Lithuania, as well as the republics of the former Soviet Union -- and possibly Albania.

Grants and other assistance to Central and Eastern Europe already account for a U.S. commitment of $1.5 billion since 1989. In Fiscal Year 1991, alone, grant assistance to the region totaled about $450 million. Many of these special assistance grants were funded through the U.S. Agency for International Development, with implementation assistance by various U.S. agencies and private sector organizations.

One important initiative under the U.S. technical assistance program was the U.S. Agency for International Development Emergency Energy Program for Eastern and Central Europe, Component #1: Industrial Energy Efficiency Improvement. This program was designed to address regional energy sector problems on a short-term basis and to identify and implement energy efficiency initiatives. This effort combined in-plant, on-the-job training with identification and implementation of energy management practices and low-cost measures to be implemented during the period of the contract work. This report outlines the activities of the Industrial Energy Efficiency Improvement project in one plant in Poland.

The purpose of the Industrial Energy Efficiency work was to improve in the short-term the efficiency of energy use by industry. Specific objectives included:

1) fostering improved management of energy use in industrial plants by identifying and implementing immediately cost-effective "low cost/no cost" energy efficiency improvements;

2) transferring energy auditing and management techniques including financial and economic analysis techniques; and

3) providing equipment to implement low-cost options, to improve monitoring and energy management, and to identify additional energy efficiency opportunities.

To accomplish these objectives the following actions were undertaken:

1) Eight industrial facilities were selected as target plants for audits. The plants were selected on the basis of:

- potential for significant energy savings;
- the likelihood that the plants will continue operating in the new economic climate;
- applicability of results to similar plants in Poland to which the energy conservation measures developed in this program could be applied.

2) Two Audit Teams went to Poland on two separate occasions, each Team visiting four or five plants to perform energy audits and conduct training.

3) The Teams identified, specified, and procured energy efficiency equipment to be used by the plants to implement short-term energy efficiency improvements.

4) Representatives of the Audit Teams returned to the plants in October 1991 to assist in implementation of the audit recommendations, and to monitor the energy improvements actually achieved.

5) The Teams presented a wrap-up workshop for plant managers and technical staff of the participant plants and other similar plants throughout the country. The seminar was held in Warsaw October 8-9, 1991.

The Industry Audit Team audited four plants (Figure 1):

Huta Ostrowiec, Steel Plant - Ostrowiec-Swietokrzyska
Zaklady Azotowe Wloclawek, Nitrogen Plant - Wloclawek
Zaklady Azotowe Kedzierzyn - Kedzierzyn-Kozle
Cement Plant Wierzbica - Wierzbica

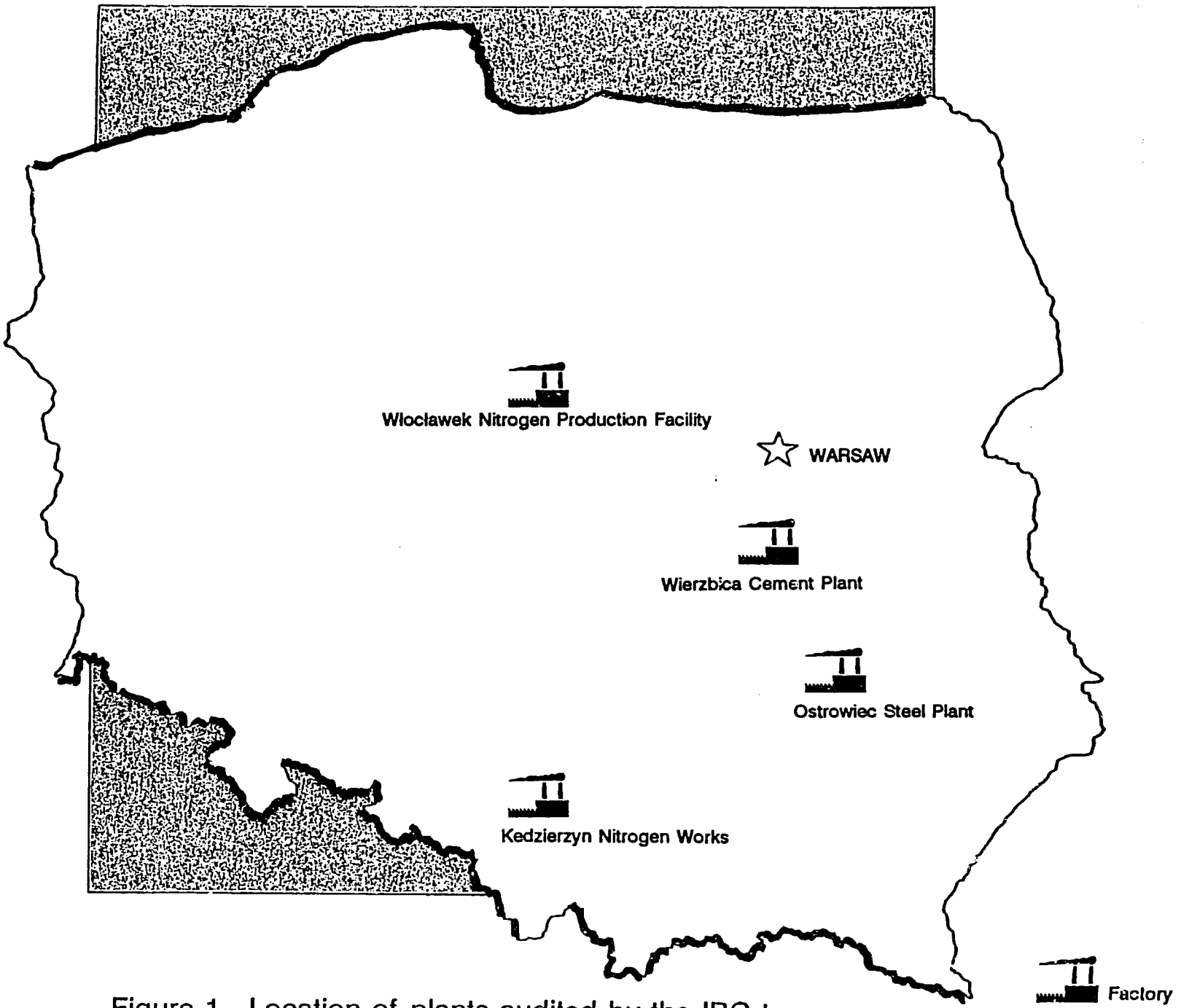


Figure 1. Location of plants audited by the IRG team.

The Audit Team collected data at every plant on the costs of producing steam and electricity, primarily using plant records, audit measurements, and interviews with plant officials. In some cases, the Audit Team counselled the plants in the establishment of systems for cost accounting in the plant, particularly where it related to energy costs per unit of output. The Industrial Energy Efficiency activities had tremendous success and generated letters of support from several plant managers.

Program Rationale

While this program was clearly a logical starting point for improved energy use patterns, it is only a beginning. Although all activities under the Industrial Energy Efficiency project were conducted using a relatively small budget for equipment purchases, the energy savings results were significant. Thus, the program demonstrated the tremendous potential for energy savings through low-cost and no-cost mechanisms. Moreover, these programs represented important energy savings initiatives that were implemented on a timely basis, within a matter of months.

These initiatives should serve as a cornerstone for a new way of approaching energy savings in Poland. They represent the lowest cost and most readily implemented energy savings initiatives available. Furthermore, the energy savings techniques/measures identified and implemented in this Emergency Energy Program should be applicable to other similar facilities and process units throughout Poland. As a result, these low cost techniques for improving energy efficiency, and thereby improving economic efficiency in industrial facilities, should serve as a model for restructuring energy use in the Polish industrial sector.

The project also highlignted a number of issues that fundamentally affect the ability of industrial entities to solve energy problems. Basic issues such as industrial energy pricing, environmental regulation, legal reforms, corporate organization and management structure, personnel training, and the overall economic environment all affect the ability of industrial concerns to implement energy savings opportunities. Thus, the Industrial Energy Efficiency Improvement project attempted to address issues of micro-level plant organization and management, training, and economic evaluation at each of the plants. In addition, the IRG Team has outlined key macro-level issues which must be addressed by the Government of Poland before comprehensive energy efficiency initiatives are enacted. These issues are addressed in this report as well as in Industrial Profile Report and the Policy and Institutional Analysis Report for Poland, both prepared as part of the Industrial Energy Efficiency Improvement project.

Ultimately, the IRG Team is convinced that the overwhelming potential for energy and cost savings in the Polish industrial sector will provide sufficient incentive for plant managers and industrial executives to actively promote the need for reforms that encourage energy conservation and improved economic efficiency.

1. EXECUTIVE SUMMARY

As part of the U.S. Agency for International Development (A.I.D.)-funded Emergency Energy Program for Eastern and Central Europe, the International Resources Group (IRG) Industry Audit Team visited Poland in April 1991. During this time, the Industry Team conducted an energy efficiency audit of the Cement Plant Wierzbica in Wierzbica, Poland (see **Appendix I** for list of activities). The overall purpose of the audit was to assist the plant in identifying low- or no-cost energy saving opportunities. In addition, Team members trained key plant personnel in methods of energy management as practiced in the United States.

To accomplish these objectives, the Industry Audit Team collected data at each plant visited to make informed decisions regarding opportunities for improving energy efficiency. Data were accumulated from several sources, including plant instrumentation, field measurements (using a portable Enerac 2000 stack gas analyzer purchased for the project), plant records, independent reports, and interviews of plant operating personnel (**Appendix III**). Information about measurements taken during the audit and general plant statistics are included in **Appendix II**.

The Cement Plant Wierzbica was included in the project based on assessments by the definitional team, which included IRG Vice President Charles Ebinger and Team Leader Gerald Decker. The Team evaluated the following issues before deciding which plants should be included in the project:

- potential for energy savings, from low cost or no cost activities;
- overall economic status (ie. would the plant survive removal of price subsidies and/or privatization?); and
- replicability of the project activities and experiences at similar plants throughout Poland.

Following the April visit, the IRG Team returned to the U.S. and arranged the procurement of equipment to be used by the Cement Plant to implement the low-cost/no-cost energy efficiency initiatives identified. After the equipment was ordered, the Team returned to Poland in October 1991 to learn the progress the Cement Plant had made in implementing the recommendations, and to provide additional advice on equipment installation and key energy management issues.

1.1 Plant Background

Cement Plant Wierzbica is a Soviet-style "Wet Process" cement production facility that has operated since 1952. This particular process used to make cement is not common outside Central and Eastern Europe, since it has been replaced in the West by the dry process for cement production. This type of plant design is inherently associated with higher energy consumption per unit of product. Consequently, in 1990, the plant consumed 225,468 metric tons (MT) of coal and 101.98 million kilowatt hours (KWh) of electricity to produce 971,000 MT

of cement. More than 65% of the electricity consumption was accounted for by the cement mills (43.31%) and the rotating kilns (21.81%).

Low-cost opportunities for energy conservation identified by the IRG Industry Audit Team principally involved improvements in process and load controls, combustion efficiency, and plant use of thermal energy. In addition, the Team recommended strategic, operational, and management changes, including product diversification, that could improve the plant's overall economic status. Since the plant is a relatively inefficient producer of standard cement, it may be possible for it to compete in certain niche markets on a worldwide basis, provided the production process becomes more specialized, and the product mix reflects the plant's comparative strengths.

Because the process itself and its accompanying plant design features are fundamentally less efficient than dry-process configurations, management staff must address the basic issue of appropriate technologies for the future of the plant. Failure to address these fundamental issues, which include consideration of the possible need to redesign the plant, may result in the plant becoming increasingly unable to compete in a highly competitive world market.

1.2 Results of the Emergency Energy Program

As part of the audit process, the IRG Industry Audit Team recommended several pieces of equipment be purchased under the Emergency Energy Program. Items purchased included:

- Infrared Thermometer
- In-Situ Oxygen Analyzer
- Load Management Personal Computer

These recommendations are summarized below in **Table 1**, and include the estimated energy savings for each item, a key criterion used in recommending the purchase of specific equipment. Given the need for high-impact results in energy savings, all equipment purchased had payback periods of one year or less. In addition, special attention was given by Team members to procuring equipment that would produce energy savings which could be easily replicated in plants throughout Poland (**see Appendices X and XI for details**).

Table 1. Equipment Procured under the A.I.D. Emergency Energy Program.

EQUIPMENT ITEM	COST	ANNUAL SAVINGS	TYPE OF SAVINGS	PAYBACK PERIOD (YRS)	COAL (TONS)
Infrared Thermometer	$427	$1,743	steam	.24	83
In-situ O_2 Analyzer	$17,470	$50,000	combustion	.35	2000
Load Management Personal Computer	$4,445	$10,000	process/ electrical	.44	n/a
TOTAL	$22,342	$61,743		.36	2083

Unlike many other technical assistance projects, the Emergency Energy Program was an action-oriented initiative, designed to demonstrate the potential for energy savings in Poland by actually implementing energy-efficiency projects in selected facilities. This report is intended to provide the reader with a background against which to view actions implemented under this project. Thus, this report outlines the observations, comments, and recommendations of the Audit Team gathered during the initial audit in April 1991, and from subsequent discussions with plant managers.

To allow a more comprehensive evaluation, specific project results will be presented in the summary report for the project. This Energy Efficiency Audit Report, however, of these report focuses on the costs, benefits, and problems associated with each energy efficiency option, and briefly outlines management, training, policy, and institutional factors that affect the ability of plants to achieve improvements in energy efficiency.

2. PLANT PERSPECTIVE

2.1 Background Information

Cement Plant Wierzbica is a cement production facility that has operated since 1952. The plant design is based on "Wet Process" Soviet technology, which is noted for its inherently higher energy consumption per unit of product. Consequently, the inefficiency of the process combined with certain energy practices cause the plant to be an ineffective energy user.

In 1990, the Cement Plant produced 971,000 metric tons (MT) of cement, although it has a design capacity of 1.1 million MT, and has produced over 1.2 million MT a year in the past. The total cement production in Poland in 1990 was 13 million MT. By contrast, in 1988 and 1989, Poland produced over 16 million MT of cement per year. Reduced trading with the USSR and the recession of 1990 have depressed total demand, resulting in reduced plant production during the past two years.

The production process, which varies significantly from the processes generally used in the West, involves a number of key features:

- raw material used in the production process is mined at a nearby quarry and trucked to the plant, where two hammer mills of 600 MT/hour each are used to crush the raw material;
- five ball mills are then used to prepare the cement sludge material, as water is added to the mixture;
- quality control (sludge correction or homogenization) is achieved in large mixing sludge pools.
- the cement sludge material is pumped to the sludge accumulators before it is fed to four baking kilns for production of clinker, the next to last stage in the production process.
- after the clinker is made, slag and gypsum are added to the mixture before the final stage of milling produces the final cement material.

The cement is produced in eight ball mills (25 MT/hour each), and sixteen concrete silos with a capacity of 1,800 MT each are used for storage. Ultimately, the cement is sold in bulk or in 50 kilogram (kg) paper bags.

The kilns used for processing are fired with pulverized coal, and there is no facility to extract sulfur dioxide (SO_2) from the flue gas. Although dust particles are collected with electrostatic precipitators (ESP), there is still a severe particulate emission problem at the plant.

2.2 Plant Statistics

Coal is the main fuel used at Wierzbica, and in 1990, plant consumption was 225,468 MT. Coal is used in several stages of production, including to fire the kilns and to dry the slag and clinker, and typically has a low heating value of 21,000 - 24,000 KJ/kg, with an ash content of 18 - 21%, volatile matter content of up to 25%, moisture content of 12 - 13%, and a sulfur content of 1.5% maximum. In 1990, Wierzbica consumed 315 kg of coal per MT of clinker (not of the final cement product).

Total electricity consumption in 1990 was 101.98 million kWh; power distribution for plant electricity consumption is shown in **Table 2** below.

Table 2. Distribution of electricity consumption at Wierzbica (1990).

Production component	% of total consumption
cement mills	43.31%
rotating kilns	21.81%
raw material mills	15.79%
compressed air	9.07%
water supply	2.34%
slag driers	1.54%
mining	1.10%
hammer crushers	0.93%
miscellaneous	4.11%

Electric power at 110 kV and 30 kV levels is purchased from the grid. In 1990, the average electric energy cost from the grid was 170 zloty/kWh ($0.018 at the April 1991 exchange rate of 9,400 zł=US $1). Electricity prices, which were heavily subsidized, became increasingly expensive in 1991 as subsidies were incrementally decreased. Although still partially subsidized, electricity prices in the spring of 1992 are more reflective of actual production costs, and are approaching world levels.

The specific consumption of electricity in 1990 was 105 kWh/MT of cement (not clinker), with energy costs for electricity and fuel comprising 27.42% of the total production cost. Based on information collected by the IRG Industry Audit Team, it was observed that plant sales in

1990 totalled 210.43 Bzl (Billion zloty), with energy costs of 46.45 Bzl, and raw material costs of 39.0 Bzl. Thus, production cost was calculated as 169.39 Bzl.

The average sale price of cement in 1990 was 216,000 zł/MT or (US) $23.00 per MT. The exchange rate used in this calculation was US $1 = 9,400 zł. However, since the audits were conducted in April 1991, the exchange rate has increased to US $1 = 10,878 zł.

2.3 Operating Status of the Plant

During the audit, the Team observed the equipment in place was relatively old and in need of repair or replacement. In addition, the Team noted that general plant housekeeping and maintenance could be substantially improved. As noted above, the process for cement production needs modernization, even though adequate financing is not forthcoming. Nonetheless, Team members attempted to identify areas in which improvements could be made to existing plant features.

One kiln was not in use at the time of audit, since it was undergoing repair. In addition, the efficiency of electrostatic precipitators was in question, since Team members observed dust and smoke emissions from the plant stacks at a distance of several miles. In light of recent movements in Poland to improve legislation for environmental protection, particularly in regard to air quality, this significant level of emissions is a potential liability for the plant that should be addressed.

Instruments in the kiln control room used to measure oxygen (O_2) and carbon monoxide (CO) were not in service at the time of the initial audit due to lack of spare parts and staff inability to calibrate the instruments. As a result, the kilns were operating inefficiently at higher than optimal levels of heat and oxygen.

The most significant result obtained during the April 1991 measurements of Wierzbica flue gas using the portable emissions analyzers was that SO_2 levels in the emissions were lower than detectable levels, registering zero readings (**Appendices VII and VIII**). This lack of SO_2 emissions can be explained by the absorbant qualities of the limestone used in cement production; limestone absorbs the SO_2, which then becomes part of the cement. This discovery has important environmental, as well as cost, implications for this and other plants using similar "wet process" technologies for cement production, since it reduces the liability for SO_2 emissions.

3. ENERGY MANAGEMENT

3.1 Energy Management Program

There is an energy management program in Wierzbica which is strongly supported by management staff; the electric power department supervises the plant's energy-management program, with the Chief Power Engineer responsible for measuring and recording energy consumption. A plant load-optimization program, designed to minimize overall electricity charges, has also been implemented. The last process energy balance made was in 1975, and showed there was little change in the process used by the plant since 1952.

Due to the lack of sophisticated instrumentation, many process variables cannot be measured; therefore, Wierzbica is prevented from adding any degree of automation to plant operations. The Soviet-designed wet process requires more energy to produce one metric ton of cement than does the modern dry process. Hence, the process itself is the biggest handicap that Wierzbica must overcome to remain competitive in the long-term. The implications of this situation are particularly apparent in the sludge correction and clinker baking stages (kilns).

In the short-term, Wierzbica is attempting to keep its operations as cost efficient as possible. Management recognizes that the plant must show a profit to attract the private investment required for privatization, and is consequently interested in cutting costs and increasing economic efficiency wherever possible.

Energy consumption data is collected at the cement plant on a daily, weekly, and monthly basis. Compared with plants such as Zaklady Azotowe Kedzierzyn (ZAK), the cement plant has far fewer resources to devote to energy efficiency programs. Nevertheless, management staff showed determination to cut production costs to save the plant and to save jobs.

3.2 Future Requirements/Recommendations

1. **Energy efficiency programs for future consideration should to be presented with supporting economic analysis.** Without economic benefits shown in writing, it will be difficult for management to compare projects and set priorities.

2. **Product diversification should be assessed.** Management must consider specialty cement markets, where product performance is of an unconventional nature (e.g. quick set cement, water-proof cement, plastic cement, etc.) to remain competitive with more efficient producers.

3. **Product extension or conversions should be considered.** Possibilities for product extension or conversion include:

   - modifying the current plant to make lightweight aggregates to supply the European market;

- extending production into semi-finished or finished concrete products - slabs, pipe/conduits, blocks, tanks, pre-stressed beams/columns; and

- entering into the pre-mixed concrete business.

4. **For the plant to compete, it must find a market niche.** Since total cement production in Poland dropped from 17 million MT in 1987 to 13 million MT in 1990 as a result of the economic downturn, cement producers have to be even more competitive to remain in operation.

5. **Economic realities will put extra pressure on energy-saving programs in the near future.** Management staff of at all levels need to be involved in energy conservation initiatives. An important goal of an energy management program is to educate all personnel about the economic implications of energy efficiency, to make clear the fact that, "Saving Energy means Saving Jobs".

6. **A target needs to be set (e.g., 3% per year reduction on energy consumption of both electricity and fuel) per MT of cement production.** The energy management program must make efficient energy use a priority so the plant will be better equipped to meet the challenge of electricity and fuel price increases in the near future.

3.3 Training Requirements

1. Economics and Project Evaluation

The personnel at Wierzbica, as in most plants visited by the IRG Industry Audit Team, had relatively little understanding of techniques used in the United States to evaluate the economic efficacy of energy investment projects. These methods include calculating:

- return on investment
- net present values
- discounted cash flow
- sensitivity.

Training key personnel to use these techniques will help the Cement Plant analyze investment alternatives and prioritize projects.

2. Long-Range Strategic Planning

The IRG Team recommends resources be devoted to formal training in strategic planning to improve corporate capabilities in this area. Development of a truly comprehensive long-term strategic plan will require:

- Forecasts of demand for electric and thermal energy;
- Analysis of corporate strengths and weaknesses;
- Analysis of competitive influences;
- Definition of alternative possible long-range courses of action; and
- The ability to evaluate alternatives.

4. ENERGY EFFICIENCY IMPROVEMENT OPTIONS

Several options to improve energy efficiency were discussed with plant management and engineers during the energy audit. Based on statistics presented by the Energy Management Team, 60% of the plant energy costs are from the consumption of coal, and 37% are from electricity. Upon further analysis of the production process, it became evident that the clinker baking stage, which includes the kilns, consumes 90% of the total coal demand and 22% of the total electricity required by the plant. The IRG Industry Audit Team recommends more efficient burning of coal in the kilns be the main target of the Energy Efficiency Improvement plan.

These opportunities were identified either as a result of test work, plant inspections, or through personnel awareness. Listed below are a variety of options for improving energy efficiency within the plant. Clearly, all these practices and projects will help conserve energy in the facility. However, given the reality of scarce resources for implementing these projects, the IRG Industrial Audit Team recommended some be given priority; this prioritization is included in **Section 5**. This section outlines the wide variety of options available for energy efficiency improvement. The ultimate decisions regarding implementation of alternative options will depend upon the criteria set by the plant management -- including acceptable payback periods -- and upon the overall corporate strategy.

4.1 Short-term Options

For the purposes of this report, "short-term" options refer to "no-cost" items which will not require hard currency, but may require small scale local currency investments, and "low-cost" items that may require limited amounts of hard currency. Each of these should be possible within the existing framework of plant expenditures (ie. zloty purchases, small hard-currency purchases, improved maintenance, and housekeeping) and will have rapid payback periods.

1. **Gas analyzers for the kiln exhaust gas are necessary to ensure the best combustion efficiency is obtained when coal is burned in the kilns.** The existing gas analyzers are of World War II vintage; there were no spare parts, and calibration had not been done for several years. The accuracy and reliability of these instruments also was in question. Engineers from Energopomiar used the portable gas analyzer, Enerac-2000, to measure the exhaust-gas composition. Details regarding these results are presented in **Appendix II**.

2. **Infrared thermometers can be used to locate defective fire brick insulation of the kilns.** An infrared thermovision device would also be effective for this task since it could give an entire picture of the kiln. Any loose or defective fire brick insulation could be detected as a hot spot. This thermometer would be used to prevent kiln burnout in the sintering section, and save major repair costs.

3. **Addition of sintering temperature measurement and coal feed control of the kiln were strongly endorsed by engineers and management.** Coal has always been overfed into the kilns to make sure clinkers were maintained above the required temperature. However, if an accurate measurement of the sintering temperature could be obtained, then it would be possible to adjust the coal feed

rate according to a critical temperature. This would result in a reduction in the coal feed rate, and ultimately the fuel cost per each ton of cement.

Estimated savings from these options in coal consumption alone would be between 5 and 10%. Additional energy benefits will be achieved in the subsequent milling of the clinker, since an over-fired clinker is much harder to grind.

Currently, the plant has one pyrometer by Simmons, installed at one of the kilns. This is intended to measure the temperature of the sintering section through radiation. At the time of audit, it measured 1,320° C. However, plant engineers suggested the actual temperature was approximately 1,450° C with the discrepancy attributed to vibrations on the mounting base of the instrument.

Team discussions with engineers from Energopomiar suggested a special type of thermo-couple (Pt/Pt-Rh), which can be made in Poland, can accurately measure temperature in that range. Special mounting can be designed to extract the electrical signal originating from the thermocouple. Furthermore, Energopomiar has the expertise to design such a system.

After reviewing further industrial statistics, the IRG Industrial Audit Team learned that the average fuel consumption of wet processes in the U.S. is one third less than that consumed in this plant (**see Appendix IV**). Thus, the potential fuel savings from short-term initiatives are extremely significant.

4.2 Medium-term/Medium-cost Options

1. **Viscosity meter to control water addition in the sludge correction tank.** In principle, the less water added to the sludge, the less coal is needed in the kilns. However, the viscosity of the sludge must be such that it will not create problems in the pre-drying section of the kiln. Water is used to adjust the viscosity of the sludge. A viscosity meter, which gives continuous readings of the viscosity of the sludge, is needed to determine and regulate the minimum amount of water addition. It, in turn, will optimize the energy efficiency of the kiln section.

   Another alternative is to install four flow control valves for the sludge tanks. Audit Team engineers suggested these valves be used to measure and control sludge flow in the sludge correction stage, thereby enabling the plant to minimize water addition.

   The estimated reduction in heat at the clinker section is 25 kcal/kg of clinker for each 1% drop of water content in the sludge. This saving translates into 114 kg of coal per hour per kiln or 549,000 zł per kiln per day (2,200,000 zł per day for the plant; US $70,200/year) for an average of 300 operating days in a year.

   Valves, as specified by plant engineers, were quoted by a Swiss firm at 54,000 Swiss francs each.

2. **Waste heat usage in coal and slag drying.** Currently slag and coal drying are done with coal fired air heaters. The amount of coal consumed by these two

heaters is some 9% of total plant coal consumption; inlet temperatures are 110 - 120° C. Under the current arrangement, 37,600 normal cubic meters (nm^3) per hour of hot air are used. Exhaust gases from the kiln at the point before the electrostatic precipitator is at 190-220° C, and the exhaust volume is 109,750 nm^3/hour.

Serious consideration should be given to exploiting the kiln exhaust gas (190-220° C) as the heat source to the dryers. There may be other variables that need consideration, such as the distance between dryers and the kiln exhaust, particulate entrapment, fan draft and flow rate, heat exchanger surface, but the 9% savings in coal burning should be a sufficient attraction to perform an economic analysis and find out the payback periods (up to U.S. $420,000 at February 1991 coal prices).

3. **Waste heat usage in hot water heating for building and domestic use.** There are four hot water boilers for building heat and domestic usage. Hot water is produced at 150° C; a heat exchanger can be installed to utilize the kiln exhaust gas (190-200° C) to generate hot water. The economics of this option may not be attractive, however, since the amount of coal saved is not significant.

4.3 Long-term/Capital-intensive Options

Only one long-term option was recommended by the IRG Industrial Audit Team; that option includes building a new plant with the latest design "dry" process.

According to the Cement Data Book by Walter H. Duda, the average thermal energy needed to produce one kg of clinker for the wet and dry process is:

800 kcal/kg	dry process
1,300 kcal/kg	wet process

Wierzbica requires 1,694 Kcal/Kg of clinker, more than twice the Western "Dry" process requirements, and 30% more than that of the Western "Wet" process.

It is not yet clear whether the raw materials and technical labor force exist in the area to facilitate implementation of this long-term option. Nor is it yet apparent that the market potential is such that this project would attract sufficient capital investment to build a new plant. Nonetheless, potential savings which might be achieved warrant further examination of this option. Moreover, the short-term and medium-term energy efficiency improvement options should be examined carefully, and, whenever possible, implemented.

5. CONCLUSIONS AND RECOMMENDATIONS

5.1 Competitive Position

The management and engineers at the Cement Plant Wierzbica were extremely helpful and cooperative during audit activities and meetings. Based on Team observations and plant engineers' input, it was possible to formulate several short-term strategies that have the potential to help Wierzbica save energy and progress toward more energy efficient operation.

Upon reviewing vital statistics for the Polish cement industry (**Appendix V**), it is evident that it will be difficult for Wierzbica to remain competitive. Ultimately, plants using the old wet process will be eliminated when facing higher power and coal costs. Therefore, management should seriously consider the suggestions made below.

The fact that the Chief Power Engineer and his associates have been conducting plant load optimization test is a sign that energy management issues are treated seriously in the plant. In addition, the fact that technical engineers investigated and evaluated different control options to reduce the specific energy consumption, is an other indication of strong support for energy management at Wierzbica.

5.2 Cooperative Seminars Held at Wierzbica

Wierzbica management is sensitive to production cost issues. Monthly seminars have been organized in conjunction with a local polytechnic university (Radom) to bring academic theorists and Wierzbica engineers together to focus on the bottlenecks in plant operations. Through these discussions, management staff hope Wierzbica will improve production efficiency (not only energy efficiency), reduce environmental pollution, and secure a better competitive position in the future. Although the seminars are informal, most chief engineers and operators at the plant are required to attend and participate in the discussions.

5.3 Privatization

Privatization was mentioned briefly by management staff during the plant visit. However, before privatization becomes a realistic option, local subsidies (housing, education, and community services) must be removed. Similarity, tax and legal frameworks for private enterprises must be established.

Wierzbica management prefers not to carry too much profit on the books, since the government takes 40% of their clear income (profit). They would also like to avoid raising worker wages, since the plant is required to pay the government a wage tax when wages are above a certain level (e.g. five zloty must be paid to the state for every one zloty paid to the workers). For the moment, management staff prefer to contract outside services rather than raise worker's wages. The regular seminars conducted by the local polytechnic university are a good example of such use of outside contractors; these services are paid for with funds from the maintenance budget.

To date, the plant is not allowed to carry depreciations on its books. This is the primary reason why the old Soviet-designed plant of 1954 is still in operation and no significant new capital investments have been made.

It is unclear what would happen to the tax structure if outside investors started to buy ownership of the Cement Plant. If the plant were fully owned by private parties, the wage tax would no longer be in effect; when only 50% is owned by private parties, however, it is not clear what the wage tax would be. Nonetheless, the more shares held by private parties, the lower the wage tax.

These are some of the questions and constraints associated with plant privatization. The complexity of these issues combined with the number of unknown variables (subsidies, taxes, laws, etc.) make it difficult for plant managers or outside experts to assess the true privatization potential of this facility.

5.4 Discussion of Options

1. Temperature measurement of sintering section of kilns - The Audit Team found no commercial temperature probe in the U.S. that could withstand the necessary 2,500° F measurement. The highest temperature measured regularly in U.S. cement plants is 2,000° F. Team findings have been communicated to Wierzbica management and to Energopomiar, the Polish power engineering firm.

   A U.S. firm, E^2 technology, indicated they have an infrared system that could solve this problem. Mr. Earnie Emery was placed in touch with Mr. Kochel of Energopomiar. In November 1991, E^2 planned a free technical seminar at Gliwice to explain the features of this system, and invited representatives of Wierzbica.

2. Portable gas analyzer - The two portable gas analyzers used by the IRG Industrial Audit Team in April 1991 had several drawbacks for use in the general environment in Poland. Team members concluded the ENERAC 2000 analyzer is sensitive to dust, and needs to be frequently calibrated in a dusty environment. Routine maintenance and re-calibrations are best done by the technical personnel of Energopomiar. However, these circumstances apply to all instrumentation that could be purchased for similar use, and as such, the particular model worked satisfactorily. Nonetheless, the plant should be aware that frequent calibrations of the device will be necessary to ensure accurate measurements.

   The main purpose of a SO_2 analyzer at Wierzbica is to periodically check levels in the flue gas intermittently to ensure the emission is within acceptable limits. There is no need to continuously monitor the SO_2 level.

3. SO_2 emission and high sulfur-content coal - SO_2 readings of the flue gas during the April audit were below the instrument's detection limit. The SO2 emissions of U.S. cement plants are kept very low even when the sulfur content in coal is as high as 1.5% to 2.7%.

This suggests limestone in the cement kiln chemically absorbs SO_2 from the combustion gas; it serves the same desulfurization function as the lime injection in a fluidized bed combustor, and the spray dryer of the coal-fired power plant. However, this chemical absorbsion is far more efficient as a result of the longer resident time and the wide temperature gradient along the kiln.

Calcium in the cement material (mainly limestone) chemically combines with SO_2 to make calcium sulfite, and becomes part of the cement.

Given that sulfur emissions will not be a problem at Wierzbica for the reasons outlined above, the new focus of low-cost/no-cost options should be to switch gradually from the coal currently used (less than 1% sulfur) to coal of 2.5% sulfur content in 0.5% increments. According to discussions, the price differential between high/medium and low sulfur coal can be more than $1.00 (USD) per MT. Using the $1.00/MT as a reference, annual savings in fuel costs from using lower grade (higher sulfur content) coal will total approximately $200,000 (USD). If this option is implemented, it will represent the most dramatic cost improvement project of all the no-cost/low-cost recommendations made by the IRG Team.

The computer purchased for this location will be used to set up a fuel optimization program (similar to the one in Kedzierzyn), so management can select the best priced coal to match kiln requirements.

4. Diaphragm valve - The US Team has not found any valves made in the U.S. that can perform comparably the sludge flow control as described by Wierzbica. Swiss made valves do not meet A.I.D. criterion for either U.S.- or Poland-manufactured products. Consequently, the team decided to postpone implementation of this project.

5. O_2 analyzer system - The four probe zirconia O_2 analyzers are to be installed, one per each kiln. The converter and the system indicator may be placed in any one of the four control booths, since the probe cable has a length of 450 meters.

6. Desktop computer - The computer purchased for this location is a high speed, computing tool (386 CPU and 33 Mhz) with tremendous memory capacity (100 Mb hard disk). It can be utilized not only to perform engineering and technical computations, but also business, finance, accounting, and information management functions.

5.5 Additional Observations

The Director of Cement Plant Wierzbica showed greater enthusiasm for energy efficiency initiatives and the plant's competitive position during the October 1991 meetings than during the meetings in April 1991. He emphasized repeatedly that time had become very critical, and the plant needed to act quickly to remain competitive. This attitude change was definitely influenced by the A.I.D.-funded industrial audit.

Given the small size of this enterprise, the management must rely on outside personnel to evaluate and implement special projects. On Wierzbica's invitation, a representative of Energopomiar's instrument section attended the October meeting at the plant.

The coal optimization project should be the highest priority activity at the plant. It should not take long to realize the benefits of coal optimization with the help of the new desktop computer.

In addition to the O_2 analyzer, the infrared thermometer, and the desktop computer, the Audit Team does not advocate other medium- or long-term projects at this stage. This recommendation reflects the fact that Wierzbica uses a Russian-designed wet process for production. The process is half as energy efficient as other modern cement plants. Consequently, it is evident that medium- to long-term investments in this inefficient technology would not be the most optimum use of scarce investment resources.

Nevertheless, since residential construction in their marketing area was very brisk this summer, the plant has been running at full production since April. Thus, at least for now, Wierzbica is still competitive in its regional market.

APPENDIX I
AUDIT ACTIVITIES
April 1991

First day (4/13)

1. A seminar of energy management was given by Jerry Decker, IRG Team Leader. A total of 10 to 12 members of the managing group attended. A question and answer session followed.
2. Introduction of IRG team members, and the CPW team.
3. Dr. Swierzawski and Dr. Wang introduced mission, objectives and goals. Three tiers of projects were explained.

Second day (4/15)

1. Plant tour - mining site, raw material crushers, sludge modification, kilns.
2. Discussion on questionnaire
3. Discussion on energy saving potential projects.
4. Reviewing supporting data on energy management.
5. Measurements of exhaust gas temperature & compositions.

Third day (4/16)

1. Discussion of measurement results
2. Prepare draft of audit report
3. Discussion on conclusions

Fourth day (4/17)

1. Presentation of audit report
2. Discussions on short term energy saving opportunities
3. More measurements of kiln exhaust gas

APPENDIX II
GAS ANALYZER MEASUREMENTS: DISCUSSION OF RESULTS

Exhaust gas measurements - conducted by the engineers from ENERGOPOMIAR.

The gas analyzer (ENERAC-2000) was used to measure the gas compositions at two locations: one at the inlet of the electro static precipitator (ESP) and two at the outlet of the ESP.

The first set of measurements were made on 4/15, and the second set of measurements were made on 4/17.

Results of first set of measurements are included below:

	Probe Position (1) Inlet of ESP		Probe Position (2) Outlet of ESP	
	Lignite (7780/ Btu/#)	Bituminous (11,700 Btu/#)	Lignite	Bituminous
Combustion eff%	81.3	83.2	78.7	70.1
Temperature C	174/27	173/26	133/25	133/25
O2%	10.5	11.6	11.7	11.8
CO ppm	8	5	720	1,724
CO2%	8.2	8.1	7.4	8.
NOx ppm	395	414	472	446
SO2 ppm	0	0	0	0
Excess Air %	107	119	121	122

Results of second set of measurements are presented below:

Probe Position: (2), Heating Value of Fuel: Bituminous/11,700 Btu/lb

	Esp on	Esp off
Combustion Eff %	84.4	84.
Temperature C	138/18	145/18
O2%	12.7	12.4
CO ppm	106	130
CO2 %	7.2	7.4
NOx ppm	322	293
SO2 ppm	0	0
Excess Air %	145	139

Discussion of gas analyzer results:

1. There was no reading of SO2 in the exhaust gas. The most probable explanation of this fact is that most of the sulfur (SO_2) from combustion must be absorbed by the gypsum and lime within the cement. This means that the calcium in the clinker may neutralize a portion of the sulfur from the coal combustion. This phenomenon, if true, implies that the clinker baking process may provide an extra capacity to absorb the sulfur from coal.

2. The oldest data of gas composition appeared in a report of 1975-1976, which measured CO2 at 29%, and O2 at 2%. During our tour of the plant, indicators showed CO2 at 22%, CO at 0.55% and O2 at 2.4%. The same instruments have been used since 1975.

3. The discrepancy between the measured CO2 and O2 concentrations may be explained in two ways: The position of probe of the portable gas analyzer was affected by air infiltration. The probe is quite short in comparison with the diameter of the conduit. Results are higher O2 concentration and lower CO2 concentration.

   The accuracy of the portable analyzer used during the audit, the Enerac 2000, was reasonably good, as the unit was new, and calibrated just before it was purchased at the end of March 1991. However, the O2, SO2, and NOx cells are known to be sensitive to moisture and dusty environments. Therefore, it is recommended to have the engineers of Energopomiar clean and calibrate the instrument on a regular basis.

Results of second set of measurements are presented below:

Probe Position: (2), Heating Value of Fuel: Bituminous/11,700 Btu/lb

	Esp on	Esp off
Combustion Eff %	84.4	84.
Temperature C	138/18	145/18
O2%	12.7	12.4
CO ppm	106	130
CO2 %	7.2	7.4
NOx ppm	322	293
SO2 ppm	0	0
Excess Air %	145	139

There was no appreciable difference in the emissions analysis when the electrostatic precipitator was on or off. There are small differences between the results of the 1st and 2nd set of measurements. Small variations were attributed to the unsteady state of fuel feed at the combustion end of the kiln.

APPENDIX III
PARTICIPANTS IN OFFICIAL MEETINGS

Cement Plant Wierzbica

Jacek Kuna	General Manager
Jan Chyb	Technical Asst. Manager
Zbyslaw Trybul	Chief Power Engineer
Adam Kornacki	Chief Mechanical Engineer
Urszula Herominska	Chief Production
Elzbieta Okroj	Chief Economist
Jan Bodzioch	Chief Technology Engineering
Edward Podraza	Interpreter

International Resources Group

Gerald L. Decker	Team leader
Dr. Frank Wang	Engineer
Dr. Tadeusz Swierzawski	Engineer

Energopomiar

Edward Magiera
Marian Warachim

APPENDIX IV
COMPARISONS OF SPECIFIC ENERGY OF CEMENT MAKING

Specific energy consumption (item 33 of questionnaire) is 0.315 kg coal per kg clinker. Also the heating value of coal given on item 22 is 21,000 to 24,000 kJ/kg. The average HV is 22,500 kJ/kg or 5,375 kcal/kg.

(0.315)(5,375) = 1,693 kcal/kg of clinker

According to ref 1. the average energy consumption for the "wet" process in western countries is 1,300 kcal/kg of clinker. Therefore, the specific energy consumption of CPW is about 31% above that of the average "wet" process.

The average energy consumption for the "dry" process in western countries is 800 kcal/kg of clinker. CPW is about twice energy intensive as that of the average "dry" process.

APPENDIX V

ENERGY CONSUMPTION AND ANNUAL CEMENT PRODUCTION IN POLAND, 1988

Specific Energy Consumption and Annual Cement Production in Poland

Wielkość produkcji - zużycie ciepła

Lp	Cementownia	Zużycie ciepła w kJ/kcal/kg klinkieru w 1988 r.	Klinkier	Cement
			Produkcja za 1988 r. w tys. ton	
I.	METODA SUCHA	4224 (1009)	5 024.2	6 552.5
1.	Małogoszcz	4700 (1124)	845.0	756.0
2.	Nowiny II	4283 (1023)	540.0	507.0
3.	Nowa Huta	4672 (1116)	124.0	752.0
4.	Rudniki	5133 (1226)	597.0	1 094.0
5.	Górażdże	3755 (897)	1 555.0	1 920.0
6.	Ożarów	3936 (940)	1 363.2	1 523.5
II.	METODA MOKRA	7226 (1726)	8 311.4	9 777.0
1.	Chełm I i II	7079 (1726)	2 037.0	2 321.0
2.	Pokój	7377 (1762)	550.0	704.0
3.	Nowiny I	7658 (1892)	800.0	850.0
4.	Przyjaźń	7173 (1714)	755.6	1 150.0
5.	Kujawy	7289 (1741)	546.6	652.2
6.	Wejherowo	12556 (2999)	32.2	30.0*
7.	Warta I	7226 (1726)	775.0	1 260.0
8.	Saturn	8202 (1959)	238.0	240.0
9.	Wiek	7633 (1823)	680.0	180.0
10.	Groszowice	7015 (1683)	280.0	312.0
11.	Odra	5610 (1340)	427.0	650.0
12.	Strezelce Op.	7218 (1724)	1 190.0	1 420.0
III.	W-wa przemiał			420.0
	RAZEM			16 749.5
IV.	Sprzedał klinkieru na eksport (po przel.)			319.7
	OBÓŁEM PRODUKCJA ZE SPRZEDAŻĄ KLINKIERU	6096 (1456)	13 335.6	17 069.2

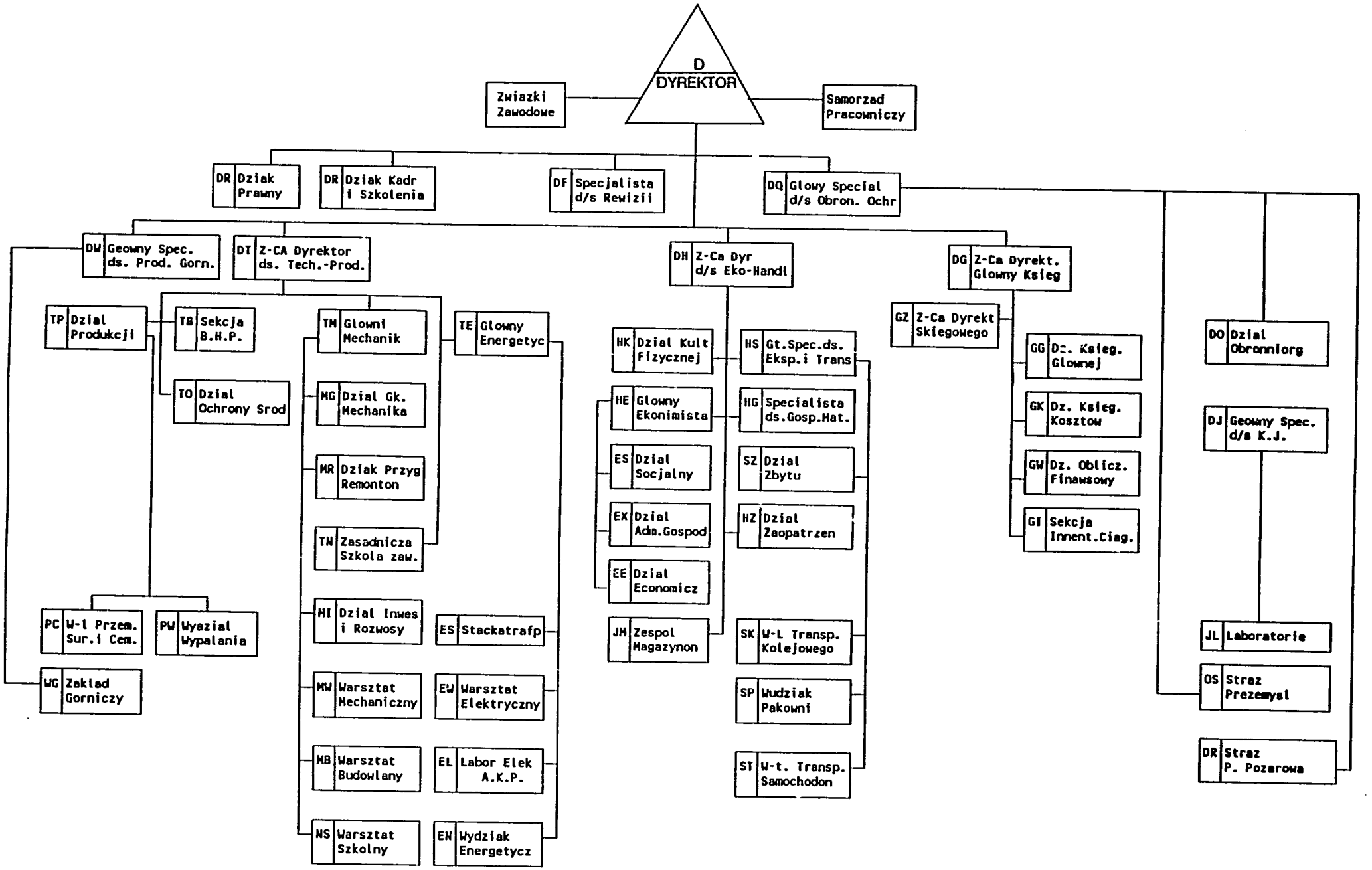
* - cement biały

22

APPENDIX VI

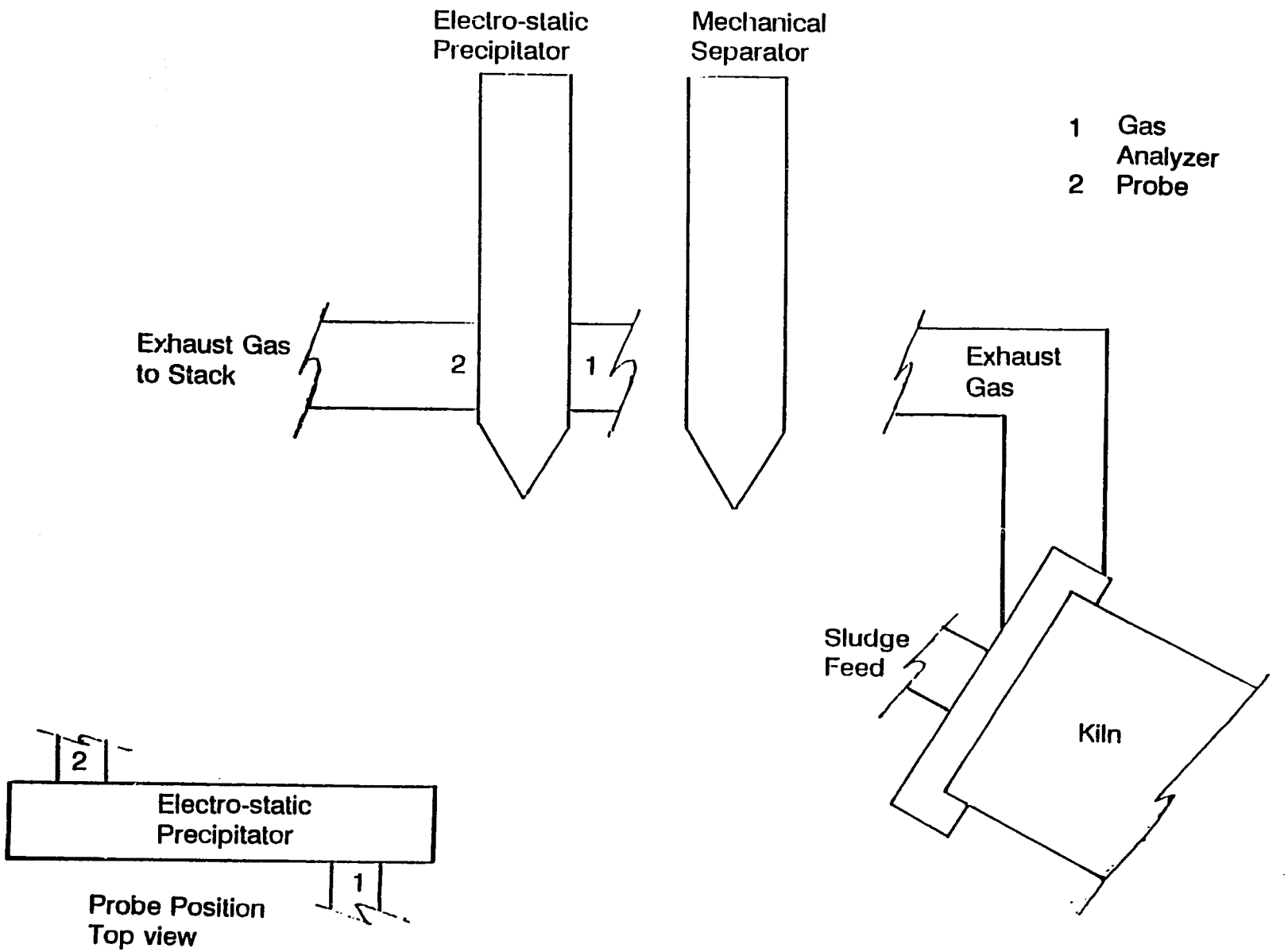
ORGANIZATIONAL CHART

APPENDIX VI. ORGANIZATIONAL CHART



APPENDIX VII

DIAGRAM OF GAS ANALYZER'S PROBE POSITION



Gas Analyzer Position

APPENDIX VIII

GAS ANALYZER MEASUREMENTS

SERIAL # 11100004

ENERAC MODEL 2000
COMBUSTION TEST RECORD

FOR: INTL'RESOURCES

TIME: 11:19:47
DATE: 04/17/91

FUEL LIGNITE: 7780 BTU/LB.

COMBUSTION EFFICIENCY:	78.5	%
AMBIENT TEMPERATURE:	18	°C
STACK TEMPERATURE:	131	°C
OXYGEN:	12.6	%
CARBON MONOXIDE:	270	PPM
CARBON DIOXIDE:	06.8	%
COMBUSTIBLE GASES:	0.04	%
STACK DRAFT (INCHES H20):	- 02.9	
EXCESS AIR:	146	%
OXIDES of NITROGEN:	313	PPM
SULFUR DIOXIDE:	0	PPM
CARBON MONOXIDE ALARM:	50	PPM

MODE:PPM OXY_REF=TRUE%

SERIAL # 11100004

ENERAC MODEL 2000
COMBUSTION TEST RECORD

FOR: INTL'RESOURCES

TIME: 11:20:26
DATE: 04/17/91

FUEL BITUMINOUS: 11700 BTU/LB

COMBUSTION EFFICIENCY:	84.4	%
AMBIENT TEMPERATURE:	18	°C
STACK TEMPERATURE:	138	°C
OXYGEN:	12.7	%
CARBON MONOXIDE:	106	PPM
CARBON DIOXIDE:	07.2	%
COMBUSTIBLE GASES:	0.00	%
STACK DRAFT (INCHES H20):	- 02.9	
EXCESS AIR:	145	%
OXIDES of NITROGEN:	322	PPM
SULFUR DIOXIDE:	0	PPM
CARBON MONOXIDE ALARM:	50	PPM

MODE:PPM OXY_REF=TRUE%

SERIAL # 11100004

ENERAC MODEL 2000
COMBUSTION TEST RECORD

FOR: INTL'RESOURCES

TIME: 11:12:00
DATE: 04/17/91

FUEL BITUMINOUS: 11700 BTU/LB

COMBUSTION EFFICIENCY:	85.3	%
AMBIENT TEMPERATURE:	18	°C
STACK TEMPERATURE:	126	°C
OXYGEN:	12.5	%
CARBON MONOXIDE:	0	PPM
CARBON DIOXIDE:	07.0	%
COMBUSTIBLE GASES:	0.00	%
STACK DRAFT (INCHES H20):	- 02.6	
EXCESS AIR:	151	%
OXIDES of NITROGEN:	339	PPM
SULFUR DIOXIDE:	0	PPM
CARBON MONOXIDE ALARM:	50	PPM

MODE:PPM OXY_REF=TRUE%

SERIAL # 11100004

ENERAC MODEL 2000
COMBUSTION TEST RECORD

FOR: INTL'RESOURCES

TIME: 11:30:55
DATE: 04/17/91

FUEL BITUMINOUS: 11700 BTU/LB

COMBUSTION EFFICIENCY:	84.0	%
AMBIENT TEMPERATURE:	18	°C
STACK TEMPERATURE:	145	°C
OXYGEN:	12.4	%
CARBON MONOXIDE:	130	PPM
CARBON DIOXIDE:	07.4	%
COMBUSTIBLE GASES:	0.00	%
STACK DRAFT (INCHES H20):	- 05.3	
EXCESS AIR:	139	%
OXIDES of NITROGEN:	293	PPM
SULFUR DIOXIDE:	0	PPM
CARBON MONOXIDE ALARM:	50	PPM

MODE:PPM OXY_REF=TRUE%

SERIAL # 11100004
ENERAC MODEL 2000
COMBUSTION TEST RECORD

FOR: INTL'RESOURCES

TIME: 10:35:20
DATE: 04/17/91

FUEL BITUMINOUS: 11700 BTU/LB

COMBUSTION EFFICIENCY:	83.5	%
AMBIENT TEMPERATURE:	20	°C
STACK TEMPERATURE:	170	°C
OXYGEN:	11.1	%
CARBON MONOXIDE:	5	PPM
CARBON DIOXIDE:	08.5	%
COMBUSTIBLE GASES:	0.00	%
STACK DRAFT (INCHES H20):	+ 00.0	
EXCESS AIR:	111	%
OXIDES of NITROGEN:	468	PPM
SULFUR DIOXIDE:	0	PPM
CARBON MONOXIDE ALARM:	50	PPM

MODE:PPM OXY_REF=TRUE%

SERIAL # 11100004
ENERAC MODEL 2000
COMBUSTION TEST RECORD

FOR: INTL'RESOURCES

TIME: 10:37:40
DATE: 04/17/91

FUEL LIGNITE: 7780 BTU/LB

COMBUSTION EFFICIENCY:	78.9	%
AMBIENT TEMPERATURE:	20	°C
STACK TEMPERATURE:	168	°C
OXYGEN:	11.1	%
CARBON MONOXIDE:	3	PPM
CARBON DIOXIDE:	08.0	%
COMBUSTIBLE GASES:	0.00	%
STACK DRAFT (INCHES H20):	+ 00.0	
EXCESS AIR:	106	%
OXIDES of NITROGEN:	492	PPM
SULFUR DIOXIDE:	0	PPM
CARBON MONOXIDE ALARM:	50	PPM

MODE:PPM OXY_REF=TRUE%

SERIAL # 11100004
ENERAC MODEL 2000
COMBUSTION TEST RECORD

FOR: INTL'RESOURCES

TIME: 11:30:09
DATE: 04/17/91

FUEL LIGNITE: 7780 BTU/LB

COMBUSTION EFFICIENCY:	78.8	%
AMBIENT TEMPERATURE:	18	°C
STACK TEMPERATURE:	145	°C
OXYGEN:	12.5	%
CARBON MONOXIDE:	304	PPM
CARBON DIOXIDE:	06.9	%
COMBUSTIBLE GASES:	0.03	%
STACK DRAFT (INCHES H20):	- 05.3	
EXCESS AIR:	138	%
OXIDES of NITROGEN:	296	PPM
SULFUR DIOXIDE:	0	PPM
CARBON MONOXIDE ALARM:	50	PPM

MODE:PPM OXY_REF=TRUE%

SERIAL # 11100004
ENERAC MODEL 2000
COMBUSTION TEST RECORD

FOR: INTL'RESOURCES

TIME: 10:36:28
DATE: 04/17/91

FUEL BITUMINOUS: 11700 BTU/LB

COMBUSTION EFFICIENCY:	83.4	%
AMBIENT TEMPERATURE:	20	°C
STACK TEMPERATURE:	170	°C
OXYGEN:	11.2	%
CARBON MONOXIDE:	3	PPM
CARBON DIOXIDE:	08.4	%
COMBUSTIBLE GASES:	0.00	%
STACK DRAFT (INCHES H20):	+ 00.0	
EXCESS AIR:	109	%
OXIDES of NITROGEN:	489	PPM
SULFUR DIOXIDE:	0	PPM
CARBON MONOXIDE ALARM:	50	PPM

MODE:PPM OXY_REF=TRUE%

SERIAL # 11100004

ENERAC MODEL 2000

COMBUSTION TEST RECORD

FOR: INTL'RESOURCES

TIME: 14:38:42
DATE: 04/15/91

FUEL BITUMINOUS: 11700 BTU/LB

COMBUSTION EFFICIENCY:	70.1	%
AMBIENT TEMPERATURE:	25	°C
STACK TEMPERATURE:	133	°C
OXYGEN:	11.8	%
CARBON MONOXIDE:	1724	PPM
CARBON DIOXIDE:	08.0	%
COMBUSTIBLE GASES:	0.54	%
STACK DRAFT (INCHES H2O):	- 06.2	
EXCESS AIR:	122	%
OXIDES of NITROGEN:	446	PPM
SULFUR DIOXIDE:	0	PPM
CARBON MONOXIDE ALARM:	50	PPM

MODE:PPM OXY_REF=TRUE%

SERIAL # 11100004

ENERAC MODEL 2000

COMBUSTION TEST RECORD

FOR: INTL'RESOURCES

TIME: 14:40:14
DATE: 04/15/91

FUEL LIGNITE: 7780 BTU/LB

COMBUSTION EFFICIENCY:	78.7	%
AMBIENT TEMPERATURE:	25	°C
STACK TEMPERATURE:	133	°C
OXYGEN:	11.7	%
CARBON MONOXIDE:	720	PPM
CARBON DIOXIDE:	07.4	%
COMBUSTIBLE GASES:	0.22	%
STACK DRAFT (INCHES H2O):	- 06.2	
EXCESS AIR:	121	%
OXIDES of NITROGEN:	472	PPM
SULFUR DIOXIDE:	0	PPM
CARBON MONOXIDE ALARM:	50	PPM

MODE:PPM OXY_REF=TRUE%

SERIAL # 11100004

ENERAC MODEL 2000

COMBUSTION TEST RECORD

FOR: INTL'RESOURCES

TIME: 15:08:59
DATE: 04/15/91

FUEL BITUMINOUS: 11700 BTU/LB

COMBUSTION EFFICIENCY:	83.2	%
AMBIENT TEMPERATURE:	26	°C
STACK TEMPERATURE:	173	°C
OXYGEN:	11.6	%
CARBON MONOXIDE:	5	PPM
CARBON DIOXIDE:	08.1	%
COMBUSTIBLE GASES:	0.00	%
STACK DRAFT (INCHES H2O):	- 07.2	
EXCESS AIR:	119	%
OXIDES of NITROGEN:	414	PPM
SULFUR DIOXIDE:	0	PPM
CARBON MONOXIDE ALARM:	50	PPM

MODE:PPM OXY_REF=TRUE%

SERIAL # 11100004

ENERAC MODEL 2000

COMBUSTION TEST RECORD

FOR: INTL'RESOURCES

TIME: 15:17:02
DATE: 04/15/91

FUEL LIGNITE: 7780 BTU/LB

COMBUSTION EFFICIENCY:	81.3	%
AMBIENT TEMPERATURE:	27	°C
STACK TEMPERATURE:	174	°C
OXYGEN:	10.5	%
CARBON MONOXIDE:	8	PPM
CARBON DIOXIDE:	08.2	%
COMBUSTIBLE GASES:	0.00	%
STACK DRAFT (INCHES H2O):	- 12.8	
EXCESS AIR:	107	%
OXIDES of NITROGEN:	395	PPM
SULFUR DIOXIDE:	0	PPM
CARBON MONOXIDE ALARM:	50	PPM

MODE:PPM OXY_REF=TRUE%

SERIAL # 11100004

ENERAC MODEL 2000
COMBUSTION TEST RECORD

FOR: INTL'RESOURCES

TIME: 10:39:17
DATE: 04/17/91

FUEL LIGNITE: 7780 BTU/LB.

COMBUSTION EFFICIENCY:	78.9	%
AMBIENT TEMPERATURE:	20	°C
STACK TEMPERATURE:	168	°C
OXYGEN:	11.2	%
CARBON MONOXIDE:	3	PPM
CARBON DIOXIDE:	07.9	%
COMBUSTIBLE GASES:	0.00	%
STACK DRAFT (INCHES H20):	+ 00.0	
EXCESS AIR:	108	%
OXIDES of NITROGEN:	489	PPM
SULFUR DIOXIDE:	0	PPM
CARBON MONOXIDE ALARM:	50	PPM

MODE:PPM OXY_REF=TRUE%

SERIAL # 11100004

ENERAC MODEL 2000
COMBUSTION TEST RECORD

FOR: INTL'RESOURCES

TIME: 10:44:38
DATE: 04/17/91

FUEL LIGNITE: 7780 BTU/LB

COMBUSTION EFFICIENCY:	79.3	%
AMBIENT TEMPERATURE:	20	°C
STACK TEMPERATURE:	168	°C
OXYGEN:	10.9	%
CARBON MONOXIDE:	5	PPM
CARBON DIOXIDE:	08.2	%
COMBUSTIBLE GASES:	0.00	%
STACK DRAFT (INCHES H20):	- 13.0	
EXCESS AIR:	99	%
OXIDES of NITROGEN:	468	PPM
SULFUR DIOXIDE:	0	PPM
CARBON MONOXIDE ALARM:	50	PPM

MODE:PPM OXY_REF=TRUE%

APPENDIX IX

ANSWERS TO THE IRG QUESTIONNAIRE

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

PART I

INDUSTRIAL ENERGY EFFICIENCY

A. Identification

1. Name of Company: Cement Plant "WIERZBICA" in Wierzbica.

2. Address: Cement Plant "WIERZBICA"
26-680 Wierzbica

3. Name of person responsible for compieting this form:
Engineer, Zbysław Trybuł

4. Title: Chief power engineer

5. Telephone No.: Radom 221-21 ext. 435

6. Telex: 067288 and 067228

Fax: 221-25

7. Industry in which the factory in classified: Construction Materials

8. Date of factory commissioning: 1952 (54)

9. No. of employees in the Cement Plant: 938

10. Working cycle - continuous running during 24 hours per day.

Yearly working cycle - continuous running. Two energetic standstills from 8 to 10 hours each are provided during one year.

11. Details regarding the Cement Plant:

a/ Supplies:

- electric energy:

  the basic power supply - overhead line 110 kV from Rożki town,
  the reserve power supply - overhead line 30 kV from Rożki town.

- coal from "Śląsk" Coal-Mine in ruda Śląska,

- gypsum from "NIDA" Gypsum-Chalk Plant in Rusko-Zdrój,

ferro-carrying powder: "SĘDZIWIR" Steel-Mill in Kraków??? anhd "ZAWIERCIE" Steel-Mill in Zawiercie;

b/ mining of raw material for production of sludge - from the mine in the region of the Cement Plant,

c/ raw material crushing - two hammer cruchers with output of 600 t/hour each,

d/ sludge production - 5 ball mills with capacity of 42 t/hour,

e/ clinker production - 4 rotating kilns with capacity of 25 t/hour,

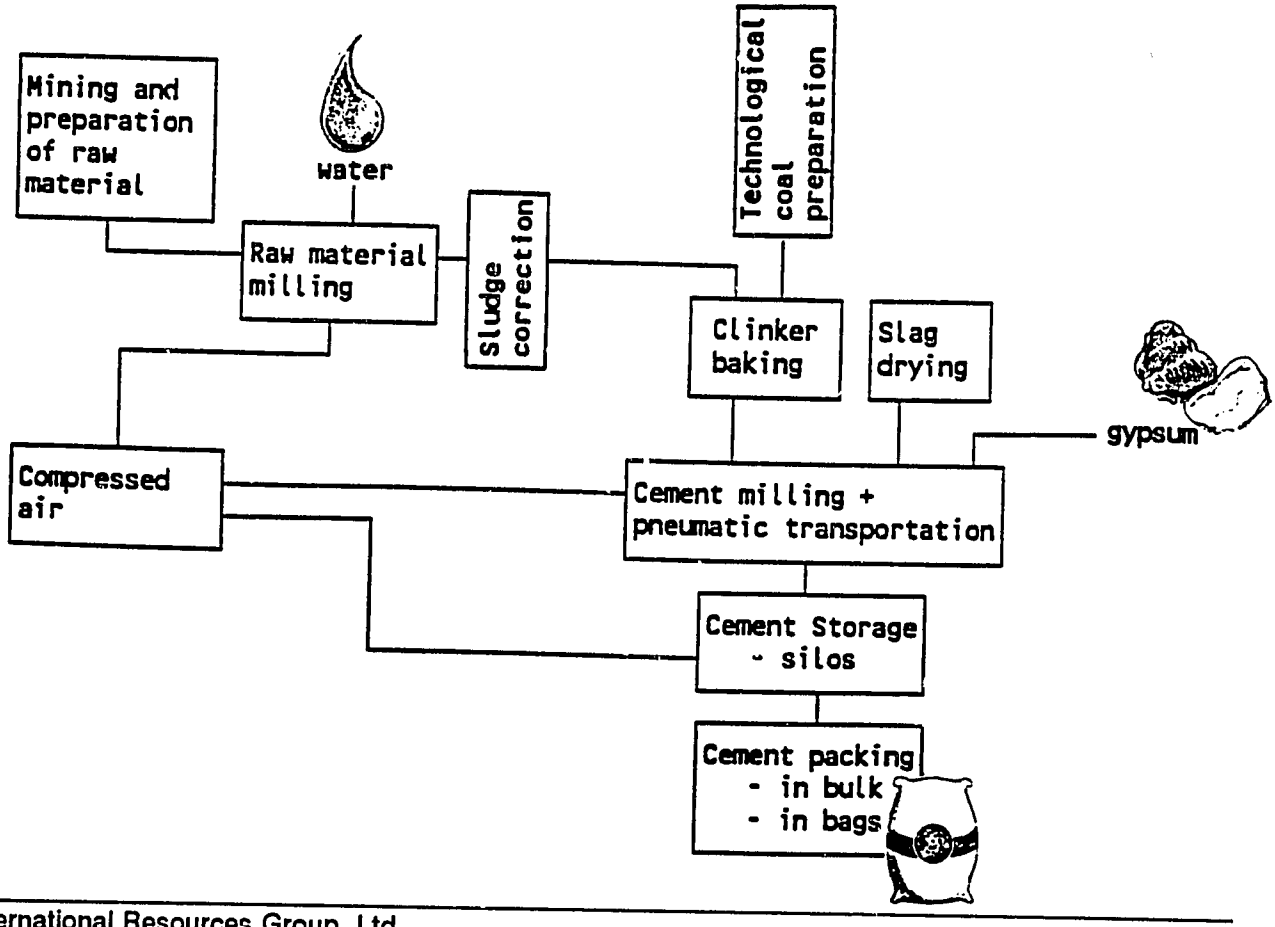
f/ cement production - 8 cement mills, ball-type, three chamber.
Capacity: 25 t/hour for each mill,

g/ cement storage - 16 concrete silos.
Capacity: 1800 cubic meters each,

h/ packing - 4 packing machines with 3 outlets each and one packing machine with 14 outlets for 50 kgs paper bags.

B. Processing Activities

12. Technological process simplified diagram of the Cement Plant:



13. Information is given in p. 12.

14. No energy balance is available in the Factory as regards the lighting. Power of the installed illumination system in approx. 800 kW.

No ventilation and no air conditioning is available in the Plant.

C. Raw Materials and Products

15. List of major raw materials consumed:
/data for 1990/

Raw material	Quantity consumed /t/	Origin	Mode of Transport to the Plant	Cost /thousands of zl/
1	2	3	4	5
Raw material	1,319,773	own	own means of transport	9,432,138
Slag	292,592	"Katowice" Steel Hill	PKP rail- - coaches	230,949
Cypsum stone	48,791	"NIDA" Gypsum-Chalk Plant	"	1,361,111
Coal	225,468	"ŚLĄSKY" Coal-Mine	"	27,954,342
Ferro- -carrying powder	9,700	"ZAWIERCIE" Steel Mill	"	not available

Remark: Column No. 3 - our preferred suppliers; further information see par. 11

16. List and quantify any recycled or re-used materials. Only clinker manufactured in the Cement Plant is used for the cement production.

17. By-products and waste products.
The dust precipitated by electro-filter in the dust extraction system of the rotating kilns returns to the "cold" ends of the kilns.

18. List of all major products:

Name of Product	Units of Production	Cement Plant Capacity	Actual annual production /t/	Selling value in thousands of zł
1	2	3	4	5
clinker	tons	750,000	650,000	4,576,794
cement /overall/	tons	1,110,000	971,000	210,129,088

Remarks:

- item No. 4 - the production in 1990,
- item No. 5 - values for sale of 31,564 t of clinker
- item No. 3 - this is production capacity

D. **Energy Supplies**

19. Energy carrier materials used in the Factory: coal, coke, petroleum products, electric energy.

20. Ways of supplying the energy raw materials to the Cement Plant.

No.	Kind of energy raw material	Way of transport
1.	Electric energy	Overhead electric line
2.	Coal	Railway line
3.	Petroleum products	Railway line, tanks

21. Current price of energy carrier materials:

1/ Electric energy - unit prices:
- peak energy - 260 zł /kWh
- daily energy - 160 zł/kWh
- nightly energy - 90 zł/kWh
- conventional power - 10,000 zł/kW
- accounting power - 18,000 zł/kW

2/ Coal:
- 194,077 zł/t - delivered by "ŚLĄSK" Coal-Mine
- 208,454 zł/t - delivered by "RUDA ŚLĄSKA" Coal-Mine

3/ Fuel oil:
- 2,850 zł/liter

22. Technical data for each kind of energy carrier material:

1/ Electric energy:
- the basic power supply: 110 kV - allowable voltage deviation ± 5 per cent,

2/ Coal:
- heating value 21,000 ÷ 24,000 kJ/kg
- ash contents 18 - 21%
- volatile matter up to 25%
- humidity 12 ÷ 13%
- sulphur contents up to 1,5%

3/ Furnace oil:
- heating value *not available*

23. For processing heat available:

	Rotating kilns	Coal drier	Slag drier
Volume of exhaust gases /Um^3/h/	109,750	11,800	25,800
Temperature /°C/	190 - 220	80 - 110	90 - 120
Gas composition CO_2 CO O_2 NOx	 24 ÷ 29 max 0.5 2		
Requirement /kJ/kg/	7.123	1.028	1.440

E. Energy Utilization

24. What process units are the major consumers of each type of energy?

No.	Production unit, group of installation	Type of energy	Quantity	Efficiency
1	2	3	4	5
1.	Cement mill	Electric energy	44,166,020 kWh	45.5 kWh/t of cement
2.	Raw material mill	Electric energy	16,097,174 kWh	14 kWh/t of cement
3.	Rotating kilns - 4 pcs with coal preparation-drying	Electric energy	22,236,798 kWh	34 kWh/t of clinker
		Coal	204,331 t	315 kg/t of clinker
4.	Compressed air production: - piston compressor - 4 pcs - rotary compressor - 5 pcs	Electric energy	9,246,549 kWh	92.1 kWh/1000 cubic meters of compressed air
5.	Slag drier - 3 pcs	Electric energy	1,573,828 kWh	5.9 kWh/t of dry slag
		Coal	18,625 t	69.19 kg/t of dry slag
6.	Hammer crusher	Electric energy	952,487 kWh	0.7 kWh/t of stone
7.	Mine - overall	Electric energy	1,125,613 kWh	0.8 kWh/t of stone
8.	Water/wheeling and transport/	Electric energy	2,386,284 kWh	0.9 kWh/cubic meter of water

25. What percentage, approximately, do energy costs represent in relation to total production costs?

    The cost of energy in relation to total production costs is 27.12 per cent.

26. No alternative fuels are provided in future.

27. Energy used for heating the buildings of the Plant in 3,780 Gcal.

28. Energy used for mechanical handling and transport within the Plant is 470,304 kWh.

29. Technological coal containers are neither heated nor insulated.

30. Seasonal limitations of energy consumption in a given time of day - are imposed by District Energy Administration.

F. Energy Consumption Data

31. The last annual data regarding consumption/for 1990/:

Fuel type	Units	Current Price	Quantity consumed	Total cost /thousands of zł
Coal	tons	Given in par. 21	225,468	27,954,342
Diesel oil I	tons	"	394	809,958
Diesel oil II	tons	"	84	354,225

Electric energy	Current price	kWh consumed	Total cost
Purchased	Given in paragraph 21	101,975,833	17,328,683

32. The overall ratio of energy consumption per unit of Plant output:
- electricity: 105 kWh/t of cement

33. Specific energy consumption ratios:
- Diesel oil for technological cars is 36,822 kgs of oil/100 carkilometers,
- coal for clinker burning/technological ratio/: 315 kgs o coal/t of clinker i.e. 6,807 MJ/t of clinker.

G. Electricity Consumption

34. The total installed capacity of motors and other equipment and voltage levels utilized:
- the total installed capacity of motors and other equipment is 33,000 kW
- voltage levels utilized in the Plant are: 6000 V; 500 V 220/380 V.

35. No electricity is generated at the Plant.

36. The ratio of electricity consumption per unit of the Plant output is 105 kWh/t of cement.

37. Through 41. Do not apply to the Plant

42. Data regarding electricity consumption are available in daily reports in the Main Supply Station/110 kV/6 kV/and in the Electric Energy Station - Division "A".

43. Electricity demand:
- peak - 18,180 kW
- average - 17,710 kW

44. Average power factor for the Plant:

- daily + peak - 0.94
- nightly - 0.96

H. Combined Heat and Power Generation

45 Through 48. Do not apply to the Plant.

II. **BOILERS**

49. Data for each boiler in the Plant:

a/ Water boiler - type WLM 2.5 - 2 pcs
- manufacturer Fabryka Kotkow "RACIBORZ"
- year of production: 1952/1 pc/; 1959/1 pc/
- water capacity - 1,200 l
- nominal flow of water 31,500 kgs/h
- water temperature at outlet 150 °C
- thermal power 2907 kW/h
- kind of fuel: coal
  - low heating value 5,000 kcal/kg
  - ash contents < 21%
  - humidity < 15%
- nominal fuel consumption
- mean efficiency 74%

b/ Water boiler - type WR 2.5 - 2 pcs
- manufacturer "Fabryka Kotłow Przemysłowych - Sosnwiec"
- year of production: 1973
- water capacity 1.47 cubic meters
- water temperature at outlet: 150 °C
- thermal power 2907 kW/h
- kind of fuel: coal
  - low heating value 5,000 kcal/kg
  - ash contents < 21%
  - water contents < 15%2
- nominal fuel consumption - 550 kg/h
- mean efficiency 79%

50. Source of boiler feed water - artesion wells:
- on the site of the Cement Plant - 2 wells
- in Dąbrówka Marszawska - 2 wells.

51. Water treatment - ion exchangers.

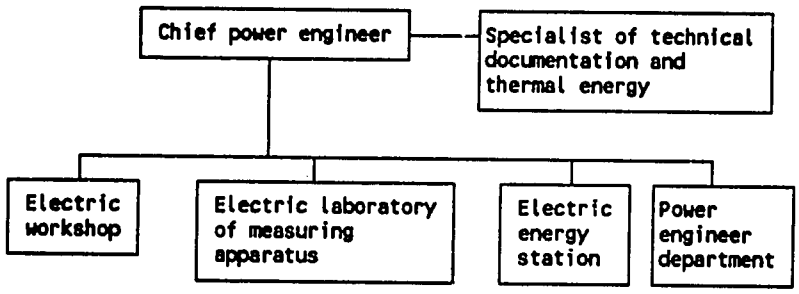
52. Re-use of condensate - does not apply to the Plant.

53. Consumption rate of hot water, including central heating
- 214,516 cubic meters.

54. Peak steam demand - there is no need.

J. Energy Management and Conservation

55. Organizational chart and brief overview of positions:



Electric workshop

Responsible for keeping the Plant electric system in good condition, for overhaul, maintenance and modernization. Manager with a few foremen is responsible for keeping the workshop and the Plant electric system in working condition.

Wiremen, fitters and welders form working groups.

Electric laboratory of measuring apparatus

The Lab is responsible for good condition of measuring instruments, automatic control system and safety devices. Manager of the Lab manages a few working groups of wiremen and automation men.

Electric energy stations

The department responsible for power supply continuity and proper distribution of the energy.

Tasks of the stations include overhaul and maintenance of the electric energy stations. The foreman with attendants is responsible for the work of this department.

Power engineer department

The department is responsible for continuous supply of the Plant with water, compressed air, proper functioning of boiler-room and sewage system. The manager of this department employs one foreman and several teams of stokers and operators of water pumps.

Specialist of technical documentation and thermal energy

- is responsible for planning and accounting of electric power in the Plant.

56. Does the Plant currently have energy savings program?

Yes, it does.

57. The energy savings program is based on modernization of the Plant. The expected savings of fuel and electricity consumption is approximately 2%.

58. The Chief Power Engineer is responsible for energy management in the Plant,
- eng. Zbysław Trybuł
- Mr. Z. Trybuł is employed in full time
- His qualification and experience - power engineer

No "energy team" is set up in the Plant but this function is fulfilled by a group of employees in the Chief Power Engineer Department.

59. There is no "energy team" in the Plant.

60. Energy conservation measures identified to date.
The main measures are based on strict adherence to technologic process.

61. Control of energy consumption is based on electricity meters.
The electricity consumed by the Plant is measured on the side of 110 kV and 6 kV. the measuring system is composed of the following measuring instruments and two separate systems equipped with:

a/ 3-phase watt-hour mater,
b/ 2-phase var-hour meter,
c/ single-phase var-hour mater.

Furthermore, two watt-hour meters are installed for receiver of 6 kV and for a group of receivers of 500 V, 3-phase and 220/380V.

62. The information and literature concerning energy conservation are not adequate.

63. The energy consumption is controlled by hourly reports of attendant wiremen. This energy consumption is restricted by District Energy Administration.

64. Analysis of energy consumption is carried out currently for the main technological equipment, for cement mills, raw material mills, for piston compressors and rotary compressors.
For the remaining equipment the analyses are carried out on monthly basis.

65. kWh and kJ are the units of measurement used in our Plant.

66. In our analysis the energy consumption is based on technological index per unit of production and on index concerning the Plant as a whole.

67. Record-keeping of energy consumption is carried out by attendant wiremen in the Main Supply Station and "A" Station. The data are recorded in shift reports by the electric and thermal energy specialist.

68. The current energy consumption is analyzed and compared daily with indices for unit of production. The consumption of coal in clinker production depends on coal quality used for the process.

69. The management is responsible for rational consumption of electric power and coal.

70. Energy data are considered important in the overall management because the cost of energy forms the major part in general factory costs.

71. All the employees are constantly educated and examined by District Energy Administration.
They have to know all the reguiations regarding the efficient use of energy.

72. There is formal system of preventive maintenance worked cut on basis of the branch instructions.
The Cement Plant is interested in inclusion of the rotating kiln technologic line into automatic control as a function of temperature in sinterins zone.

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

Component #1
Industrial Energy Efficiency

Energy Audit Questionnaire

A. Identification

1. Name of Company/Plant:
2. Address:

3. Name of Person Interviewed/Completing Form:
4. Title/Position:
5. Telephone:
6. Fax (or Telex):

7. Industry in which the factory is classified:

Mining	Construction Materials	Paper
Textiles	Mechanical/Electrical	Chemicals
Oil Refining	Food Processing	Steel
Other		

8. Date of factory commissioning:

9. Number of Employees:

10. How many hours/day does the plant operate (average)? Days per year (average)?

11. Please provide details on plant operation (eg., procurement, fabrication, scheduling, inspection, packaging, storage, shipping).

B. Processing Activities

12. Provide a flow sheet of the plant indicating major operations.

13. List the different process units (manufacturing stages), eg., boiler, electricity generation, oxygen plant, compressed air.

14. Provide a materials and energy balance for such non-process functions as lighting, heating, ventilation, air conditioning (if any), and materials handling.

C. Raw Materials and Products

15. List all major raw materials consumed:

Raw Material	Quantity Consumed	Origin	Mode of Transport to the Plant	Cost

16. List and quantify any recycled or re-used materials.

17. Are by-products or waste products of this plant utilized elsewhere?

18. List all major products:

Product	Units of Production	Plant Capacity	Actual Annual Production	Value of Sales

E. Energy Utilization

24. What process units/departments are the major consumers of each type of energy?

Process Unit	Type of Energy	Quantity	Efficiency

25. What percentage, approximately, do energy costs represent in relation to total production costs?

26. List any alternative fuels that could be used with or without modification of the plant.

27. How much energy is used in heating/cooling buildings?

28. How much energy is used for mechanical handling and transport within the plant?

29. Are fuel oil tanks heated? If so, how are they heated and how is the system controlled?

30. Does the plant encounter energy time of day or seasonal energy demand constraints (especially for electric power and natural gas)?

F. Energy Consumption Data

31. Give the latest annual consumption data:

Fuel Type	Units	Current Price	Quantity Consumed	Total Cost

Electricity	Current Price	kWh Consumed	Total Cost
Purchased:			
Self-Generated:			

32. What is the overall ratio of energy consumption per unit of plant output (eg., GJ/product unit)?

33. Give specific energy consumption ratios for different fuels used (eg., million metric tons of fuel oil/product unit).

G. Electricity Consumption

34. What is the total installed capacity of motors and other equipment (kw)? Specify voltage levels utilized.

35. Is electricity generated at the plant?

36. What is the ration of electricity consumption per unit of plant output (eg., kWh/product unit)?

37. If yes, what type of generator is installed (eg. diesel, gas turbine, steam turbine, waste heat boilers)?

38. What self-generating capacity is installed? (kw)

39. How much electricity was generated by the plant last year (kWh)?

40. Fuels used for self-generation:

Fuel Type	Units	Quantity Consumed	Heat Content of Fuel

41. Is self-generation capacity to be increased?

42. Are there data available on daily and seasonal variations in electricity consumption? Is there a daily load curve available?

43. Give electricity demand: peak and average.

44. What is the average power factor for the plant?

H. Combined Heat and Power Generation (Cogeneration)

45. Is there a cogeneration system installed at the plant?

46. If yes, provide the following:

Energy Source.	Level of Heat Production (GJ/hr)	Level of Steam and Elec. Prod. (kw)

47. When was the system installed?

48. Are there plans to install cogeneration systems or to increase the capacity of an existing system?

I. Boilers

49. Provide data for each boiler:

Maker:

Type/Model:

Capacity:

Steam Pressure:

Temperature:

Normal Consumption of Fuel:

Fuels Used:

Average Efficiency:

50. What is the source of boiler feed water?

51. What water treatment is used? What is the water quality after treatment?

52. What percentage of condensate is re-used?

53. What is the consumption rate of water?

54. What is the peak demand for steam?

J. Energy Management and Conservation

55. Provide an organizational chart and brief overview of positions, responsibilities, management policy directives, internal accounting policy, and quality assurance policy.

56. Does the plant currently have an energy conservation/savings program?

57. If yes, what does this program consist of? What are the energy savings?

58. Who is responsible for energy management?

Name:
Position:
Full Time/part time?
Qualifications, Experience?

Is there an "energy team"? If so, how many?

59. Is there an "energy committee"? If yes, list the members of the committee and their titles. What are the tasks and responsibilities of the energy committee?

60. What energy conservation measures have been identified to date?

61. What instruments/equipment are currently available to conduct energy audit work?

62. Does the plant have adequate information and literature concerning energy conservation and audit procedures?

63. How is energy consumption examined and controlled?

-- by senior management only? by each plant within the company?

-- as a routine matter, or from time to time?

-- when was the last complete review performed?

64. What analysis of energy consumption is carried out?

- According to department (eg., offices, process plant, maintenance)?
- By major equipment (eg., furnaces, boilers, electrostatic fillers)?
- By end-use (eg., lighting, process heat, rotating equipment)?
- By major product line?
- By total monthly consumption?

65. What units of measurement are used? Are the consumption patterns of different forms of energy converted into a common unit of measurement?, eg., kilocalories, BTU, or kWh?

66. Does the analysis include study of the relation between energy used and level of production?

67. Describe the present extent of record-keeping of energy consumption for all forms of energy consumed. Are records available of the energy consumed in the different parts of the plant? By major individual consuming equipment? By department?

68. Is the current energy consumption compared with energy consumed in previous periods, or with other similar plants? Are adjustments to energy consumption made for variations in products quality, in the quality or type of raw materials, in climatic conditions, in capacity utilization?

69. Are specific, quantitative objectives set by management?

- for total energy consumption?
- for specific energy consumption?
- for energy savings (eg., percentage reduction)?
- for improvements in specified processes or manufacturing stages?

70. Are energy data considered important in the overall management information system?

71. What action has been taken to educate personnel in energy conservation procedures?

72. Is there formal system of preventive maintenance? (Give details).

APPENDIX X

EQUIPMENT JUSTIFICATIONS AND SPECIFICATIONS

The recommended equipment is listed in order of priority. All equipment supplied must be in metric units, 220 volts/50 hertz, with a two year supply of consumable and critical parts (spares). In addition, two operating and maintenance manuals and appropriate batteries and/or chargers must also be provided. Complete units with all parts for operation to be supplied for use in Bulgaria. All required equipment to be provided, instrument air at 6.5 Bar (Dry) available and delivered to user at 20 PSI. Quotations should provide a complete installation sketch and description of all equipment supplied.

1. **Portable flue gas and emissions analyzer.** ENERAC 2000 or equivalent, to determine volume % (dry basis) CO_2, CO (to 0.2 % or preferably higher), O_2, SO_2, NOx, soot and combustible hydrocarbons. Unit to indicate, and if possible to print out, results. Also to indicate temperature to at least 1,100 °C and to serve as a draft gauge, reading to plus and minus 100 mm of water relative to atmospheric pressure. Must be durable.

2. **Portable temperature indicator for reading skin and internal temperature** to approximately 1,600 °C. Accuracy 99.8 % over entire range.

3. **Infrared Thermometer.** Davis Instruments or equivalent capable of reading surface temperatures, in order to identify heat losses.

Details on the energy and cost savings associated with these items are included on the following page.

Name of Company: Cement Plant Wierzbica Location: Wierzbica, Poland Type of Industry: Cement					Total Energy Savings
I. LOW-COST EQUIPMENT	COST	ANNUAL SAVINGS	PAYBACK PERIOD (YRS)	TYPE OF SAVINGS	GAS (m^3) COAL (tons) ELECTRIC (kwh)
Emissions Gas Analyzer IR Thermometer (savings est. w/temp indic.) Portable Temperature Indicators	$11,697 $ 892 $1,942	$230,000 $5,520	0.05 0.43	combustion/heat/loss loss combustion/heat loss combustion	20,000.00 48,000.00
EQUIPMENT SUBTOTAL	$14,531	$235,520	0.06		204,480.00
II. NO-COST SAVINGS					
NO-COST SUBTOTAL	$14,531	$235,520	0.06		

(ENERGY COST ASSUMPTIONS)
Natural Gas - 1725 leva/1000 m^3
15 leva = $1 US

APPENDIX XI

EQUIPMENT LIST
CEMENT PLANT AT WIERZBICA

1. One set of O2 analyzer by Johnson Yokogawa which contains:

   - four (4) probes with zirconian cell, #Z021D-L-100-A*U
   - four (4) probe protectors, #Z021R-L-100-A*U
   - one averaging converter, #AV8G-47AS-AE*A
   - one system recorder,#4176-500-71/BU;

2. IBM compatible personal computer, Model ASY 386SX-33 MHZ, 2MB mem,w/2FD(1-1.2; 1-1.44); AT I/O, 101 KB,100 MB Conners IDE HD; SVGA Color Monitor(1024 RES); Alps printer/6 ft cable, 24 pin,132 col wd, LQ: op & M/S manuals; and Lotus 123 software ver 3.1

3. One infrared thermometer, Cyclops 3 by Davis Instruments.

The current staff at Wierzbica have only limited skills in using desktop computers. As such, it is unrealistic to expect the staff to take full advantage of this new tool from the outset, without additional training. However, with an introductory course and practical workshop on desktop computers, tailored to specific plant needs would greatly increase personnel skills, proving to be a productive technical assistance initiative that would complement the goals and objectives of the Emergency Energy Program Industrial Energy Efficiency Project.