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BURNS AND ROE ENTERPRISES, INC.

Audit Report
KIEV ARTISTIC GLASS FACTORY
KIEV, UKRAINE

FINAL

August 1997

Prepared by:	**Resource Management Associates of Madison, Inc.**
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RESOURCE MANAGEMENT ASSOCIATES
of Madison, Inc

RMA/UKR-DO6-R-06

Delivery Order # 6 - Ukraine: Energy Efficiency and Reliability
Task #3 - Industrial Energy Efficiency
Subtask #6 - Energy Audits

KIEV ARTISTIC GLASS FACTORY
Kiev, Ukraine

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Preface

The work described in this report is being carried out by Resource Management Associates of Madison, Inc (RMA), within the framework of the U S Agency for International Development (USAID) Emergency Energy Program for the Newly Independent States (NIS), under contract with Burns and Roe Company, NIS Energy Efficiency and Market Reform Project, Contract Number 5826-001-DO5906-03

This is a working document published informally by RMA This report has been prepared in a working document format, in the interest of timeliness, to present the results of the project with light review

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1. 0 EXECUTIVE SUMMARY

As part of Delivery Order #6 of the NIS Energy Efficiency and Market Reform Project, the United States Agency for International Development (USAID) sponsored a total of five industrial energy audits at large energy consuming industries in Ukraine Two of the audits were completed by Resource Management Associates (RMA) of Madison, Inc. located in Madison, Wisconsin USA One plant was audited by Burns and Roe Company, and two plants were audited by Foster Wheeler Company. This report details the findings of RMA's energy audit performed at the Kiev Artistic Glass Factory located in Kiev, Ukraine.

The five industrial audit sites were selected under previous activities within this Delivery Order Ukrainian agencies and the Ukrainian IDEA staff worked with the auditors to identify potential sites Ukrainian industrial energy data was obtained from Arena-ECO and the Ministry of Electrification This data was provided on a sector-by-sector basis and on a fuel-type basis In addition, typical plants within the top sectors were identified as possible audit sites Site visits to each plant were coordinated by the IDEA staff, team leaders from RMA and Foster Wheeler reviewed these facilities in order to select the five most appropriate sites Each facility was evaluated based on several criteria, including energy intensity, total annual consumption of energy, total annual consumption of electric energy, importance of the product to the Ukraine economy, and plant viability. In addition to the Kiev Artistic Glass Plant in Kiev, the following four plants were selected Zaporozhye Coke and Chemical Plant (also audited by RMA), Strojindustrial Building Materials in Kiev, Komunar Car Plant in Zaporozhye, and Donetsk Metallurgical Plant in Donetsk Following plant notification, audit schedules were coordinated, and the audits were conducted

The objectives of the energy audit objectives were to

- Promote the importance of energy conservation to successful plant operation
- Identify short payback energy conservation projects utilizing US equipment
- Identify large energy conservation opportunities requiring further investigation.
- Transfer hands-on energy auditing experience to plant staff and a local engineer

The audit follow-up activities will

- Report on energy audit findings
- Specify USAID funded energy conservation equipment
- Implement specified conservation equipment upon USAID approval.
- Monitor energy savings seen by conservation equipment implementation
- Conduct a workshop in Ukraine to promote results of demonstration conservation projects

The Kiev Artistic Glass Factory produces crystal glass pieces, including plates, bowls. glasses, and decorative figures The glass is made by melting sand with lead oxide to produce crystal glass

The glass is then formed in molds or manually shaped by glass blowing, during which air pockets are created in the glass by workers blowing on the glass as they work it with hand tools To remove stresses, each piece is reheated and allowed to cool slowly Polishing and inspection complete the production process These products are sold within Ukraine

The glass plant's 1994 average annual energy consumption (based on energy content) included

Purchased Electricity	31%
+ Purchased Natural Gas	69%
Total	100%

The audit covered the following areas of the plant glass production furnaces, glass annealing ovens, plant ventilation, heat distribution system, air compressors, a flue gas exhaust system, and existing energy management practices

Upon completion of the plant audit, the auditors identified six short-term "energy conservation opportunities" (ECOs) which met the audit objectives They are as follows (see *Table 1.1* for a summary of these recommendations)

ECO #1 Glass Furnace Combustion Air Control
ECO #2 Ventilation Fan Energy Efficient Motor Replacement
ECO #3 Glass Reheating Stove Heat Recovery
ECO #4 Glass Annealing Oven Infiltration Reduction
ECO #5 Molten Glass Holding Furnace Burner Efficiency
ECO #6 Energy Management Program Enhancement

These measures were discussed with plant management who agreed to make these energy efficiency improvements if they were provided with the materials and technical assistance not available at their facility

The conservation opportunities identified have a cumulative first-year energy cost savings of $40,586 at local energy prices and $220,156 at world energy values This represents an 8 2% reduction in consumption compared to consumption during 1994 These savings can be accomplished with a total investment of $101,500 Financial payback of this investment is 2 49 years, using current local energy costs, and 0 46 years at world energy values Methods to quantify energy savings from the above recommendations are found in Section 8 of this report

Opportunities for energy conservation not covered under the scope of this demonstration project are identified in Section 5 titled "Long Range Opportunities"

Table 1.1 Summary of Identified Energy Conservation Opportunities (ECOs)

ECO #	DESCRIPTION	ANNUAL FUEL SAVED	ANNUAL ENERGY SAVED	ANNUAL $ COST SAVING		PROJECT COST ($ US)	SIMPLE PAYBACK	
				World Energy Prices	Local Energy Prices		World Energy Prices	Local Energy Prices
1	Glass Furnaces # 1 & #3 Combustion Air Control	255,148 m^3 of natural gas	2,043 5 Gcal (8,108 3 MMBtu)	32,444	5,613	14,000	0 43 years	2 49 years
2	Ventilation Fan Energy-Efficient Motor Replacement	30,400 kWh of electricity	7 8 Gcal (31 1 MMBtu)	973	213	2,320	1 19 years	5 45 years
3	Glass Reheating Stove Stack Heat Recovery	173,685 m^3 of natural gas	1,391 0 Gcal (5,519 5 MMBtu)	21,937	3,790	22,400	1 02 years	5 91 years
4	Glass Annealing Oven Infiltration Reduction	53,460 m^3 of natural gas	428 2 Gcal (1,698 9 MMBtu)	6,800	1,176	No Outside Cost	Immediate	Immediate
5	Molten Glass Holding Furnace Combustion Air Preheating	137,532 m^3 of natural gas	1,191 5 Gcal (4,370 6 MMBtu)	17,496	3,026	20,000	1 14 years	6 61 years
6	Energy Management Program Enhancement	845,000 kWh of electricity plus 679,450 m^3 of natural gas	218 0 Gcal (864 9 MMBtu) plus 5,441 7 Gcal (21,592 2 MMBtu)	140,506	26,768	35,000	0 24 years	1 26 years
	TOTALS	873,162 kWh of electricity and 1,299,275 m^3 of natural gas	10,631 7 Gcal (42,185 5 MMBtu)	220,156	40,586	101,500		

2.0 INTRODUCTION

Fifteen newly independent states (NIS) emerged from the dissolution of the Former Soviet Union (FSU) in 1991 The United States Agency for International Development (USAID) is addressing and managing assistance to these countries Initial assistance efforts have revealed considerable opportunities to reduce energy consumption and environmental degradation

Presently, industries in the NIS are unable to compete in the world market place due to inefficient plants To modernize these plants, the states need to have the hard, stable currency that exports would generate Energy efficiency improvements would contribute production cost reductions

The Ukrainian Government has embarked on a plan to reform the energy sector by eliminating institutional disincentives to energy conservation The objective of this USAID project is to prepare the groundwork for these coming reforms by (1) demonstrating the savings that can be achieved in selected industries and (2) introducing modern energy management principles to the organizations and local engineers Efforts to meet this objective included a program which selected target plants according to pre-established criteria, conductedenergy audits, installed selected instrumentation and energy savings equipment, identified low-cost/no-cost actions, identified necessary larger investments, and trained plant personnel in sound energy management

During February of 1995, an energy audit was performed at the Kiev Artistic Glass Plant RMA performed this audit along with plant technical staff and a local engineer from the Kiev Electrical Utility (Peter Garkoun) The RMA audit team consisted of Yevgeny Guterman and Doug Presny

This report details the findings and analysis of the RMA audit team at the Glass Plant Included are low-cost, short payback energy conservation opportunities, equipment specifications to facilitate implementation opportunities, and long-range energy conservation opportunities which justify further investigation In addition, results of training conducted during the audit are included

A kickoff meeting was held with plant management, representatives of USAID and IDEA-PADCO[1], and the audit team A discussion introduced the project and its objectives The plant staff appeared supportive of the concept A plant tour was conducted to identify the plant's energy-consuming areas (see Appendix B, photos #1 & #2)

Following the plant tour, plant staff and the auditors agreed upon an audit schedule Areas of investigation included

- Natural gas fired glass making furnaces

[1] IDEA-PADCO is a subcontractor working in support of USAID

- Electrically heated glass making furnaces
- Heated ventilation system
- Glass annealing ovens
- Glass re-heating ovens

Upon completion of the plant audit, a preview of the recommendations was discussed with the plant management, including the energy manager and the department responsible for new technologies Agreement was reached for each of the recommendation concepts The plant management indicated agreement to host the USAID-funded demonstration of the technologies Upon USAID funding approval for the equipment to be installed, a written proposal should be made to the plant This will verify their agreement to install and monitor the specific equipment to be purchased

3.0 FACILITY BACKGROUND

3.1 Description of Facility

The Kiev Artistic Glass Factory has about 2,000 employees and is currently state owned It is in transition to a private stock-owned company (see advertisement in Appendix C) In operation for 110 years, this factory produces both molded and hand-blown crystal glass pieces (see Appendix C for sample of product catalog) Crystal glassware, vases, sculptures, platters, and commemorative art is produced at this facility Technology within the plant ranges from workers manually shaping glass to automated machinery which mold glass Approximately 100 different glass products are produced at this facility The plant maintains a museum display representing its past works including pieces completed for the Former Soviet Union's government leaders

Crystal glass pieces are made by heating a mixture of white sand and lead oxide to a glowing orange molten state The molten glass is then shaped either by pressing it into molds, or shaping it manually by air and metal hand tools Final finishing of the crystal glass pieces is done with a combination of abrasive and acid

Kiev Artistic glass factory is one of oldest plants in Kiev The facility has been modified many times during its 110 year history Until about 1950, the plant produced very basic items, such as bottles

The plant is divided into two main shops with a total of eight glass melting furnaces Two natural gas and two electric ovens are presently in operation Ovens are kept in continuous operation due to damage which occurs when they are cooled It takes two months to repair an oven following stress damage which occurs from cooling Ovens are kept hot even if production is halted due to lack of materials This happened for a period of two weeks in 1994

The plant uses natural gas in three other production locations Burners are used to reheat glass while being hand molded, to keep molten glass-holding reservoirs warm, and to anneal finished pieces of glassware

The plant has a division of responsibility known as the thermal and power shop This shop provides production of compressed air, space heating water, process steam, and process water

3.1.1 *Management Structure*

Presently a State-owned company, the plant is planning to privatize (see advertisement in Appendix C) Shares in the company are available for purchase, but it was not clear what percentage of the shares will be sold and how many will be held by the State

Since the plant is not presently subsidized or regulated by the State, it appears that privatization will not change the plant in the short term Transition to a private organization is consistent with current policy, but not likely to affect major change

This facility is directed by a general manager The plant's chief engineer makes all operational decisions Energy-consuming issues are the responsibility of the chief power manager Because of thissimple management structure, it appears that energy decisions could be made and implemented with relative ease (See Appendix E for a list of contacts made at this facility)

3.1.2 *Hours of Operation*

All process areas audited are in continuous operationy Typically, the main glass furnaces shut down once every three years for preventive maintenance Although a lack of raw materials has stopped production previously, the ovens still remain heated for maintenance reasons Auxiliary burners and equipment are shut down when not in use

3.1.3 *Viability of Facility*

The management reports a steady demand for their unique goods This is the only facility of its kind in Ukraine Since there is not much of a middle class in Ukraine, products are tailored to the practical needs of the poorer consumers or to the artistic desires of the wealthy

Facility output is expressed in annual revenue rather than numbers of pieces of production This is because each piece may require varying amounts of effort To normalize this, gross sales is used as an indicator of production After accounting for currency fluctuations, 1994 production was equal to that in 1991 At present, the plant produces greater numbers of lowe- priced goods for domestic sales and fewer high-priced goods for the international market Plant management reported that international competitiveness was blocked by high state export taxation and high railroad transportation costs Countries such as the Czech Republic, Germany, Finland, and Italy produce similar exported products at more competitive prices

Plant production indicators show similar plant utilization over the past four years Although product types have changed, sales and energy consumption have remained constant (see Appendix B) The energy portion of production costs (including payment for utilized water) has risen from 10 8 % in 1990 to 27 9 % in 1994

Production revenue is not expected to significantly change The plant has the flexibility to modify production to meet consumer demand As the Ukrainian quality of life increases, more artistic goods will be salable domestically

The majority of goods sold by the plant today are very practical in nature (glasses, plates, bowls) This is because the majority of the domestic market can only afford to purchase "necessities", not artistic pieces If the cost of energy increases to the point where even practical items cannot be

afforded, this market will be lost The plant is very aware of this, and is enthusiastic about energy conservation

3.2 Energy Conservation History

The chief power manager is the person responsible for energy conservation His responsibilities also include the operation and maintenance of process support equipment In the past, his duties have largely been focused on keeping equipment operational rather than maximizing energy efficiency Because the plant does not make a large profit, investment is based on keeping the plant operational

The biggest obstacle to investments in this area is the lack of information regarding energy conservation savings Currently, there is no metering available to quantify the energy which could be saved if improvements were made If there were a clear understanding of how energy conservation directly leads to profit increases, conservation implementation would be more aggressive

The plant is presently missing the opportunity to reduce small energy losses, which add up to significant ones Uninsulated small-diameter piping, high oven wall temperatures, and open doors on ovens while heating are examples of missed opportunities

One conservation measure implemented in the past was installation of heat recovery boilers on glass furnaces #1 and #3 The capacity of each of these boilers is 1 Gcal per hour They produce steam used for the glassware finishing phases The boilers were tested after installation, but have not been used since There was no interest in using them again, but the audit team was not able to learn why this might be There was interest in providing heat recovery in other areas, so the reason for not utilizing these boilers was unclear

This facility did not have a specific payback requirement for making investments in the facility General discussion indicated that a payback of one year or less would be attractive for in-plant funding

3.3 Facility Energy Use

3.3.1 *Consumption*

With all sources of energy converted to heat value, Kiev Artistic Glass Plant uses a combination of two-thirds natural gas and one-third electricity The plant uses both electricity and natural gas to make glass (see *Table 3 2 - 3.4*) The energy cost to produce one Gcal of heat is significantly cheaper with natural gas Using natural gas with 70% efficiency still costs only one-third the cost of using electricity with 100% efficiency Given present pricing, the plant should look toward maximizing use of natural gas as a heat source to make glass Since the two newest stoves are

electrically heated, there may be production factors which influence this If feasible, maximizing gas would reduce plant energy costs and potentially help Kiev's over-burdened electrical supply[2]

Table 3.2 Energy Purchased by the Kiev Artistic Glass Plant

ENERGY TYPE	UNIT	CONSUMPTION 1994	SOURCE
Electricity	kWh	16,900,000 / year	Kievenergo
Natural Gas	Cubic Meters	13,589,000 / year	Kievgas

Table 3.3 Energy Consumed at the Kiev Artistic Glass Plant Based on Heating Value

ENERGY TYPE	UNIT	CONSUMPTION 1994	PERCENTAGE
Electricity	Gcal @ 30% delivery efficiency	48,454 / year	31%
Natural Gas	Gcal	108,832 / year	69%

[2] The natural gas used to heat ovens would displace the natural gas used to generate electricity The benefit would depend on the delivery efficiency of the electricity

Table 3.4 Cost of Energy Consumed at the Kiev Articstic Glass Plant

ENERGY TYPE	UNIT	COST IN US $ (World Prices)	COST PER UNIT- US $ (World Prices)	PERCENT OF BUDGET
Electricity	kWh	$237,310 / year ($1,081,600/year)	$0 014 ($0 064)	44%
Natural Gas	Cubic Meters	$298,705 / year ($1,727,418/year)	$0 0220 ($4/MMBtu)	56%

3.3.2 *Energy-Using Systems*

The plant's largest energy-consuming process is making molten glass This is accomplished by adding heat to sand The heat is supplied by natural gas in two furnaces and by electricity in two other furnaces Once the molten glass is made, natural gas is used to keep the glass hot and to reheat glass while being processed Increased combustion efficiency and the recovery of heat lost in flue gasses offer large energy saving potential

Electrical furnace heaters use the most electricity in the plant Motors for worker ventilation fans are the second largest electricity user Lighting is an insignificant portion of the plant's electrical load High-efficiency motors offer great potential for easily installed energy savings in this area

A break-down of energy uses by type follows

ELECTRICITY

1	Electric glass making furnaces	45 %
2	Plant exhaust ventilation fans	40 %
3	Compressed air production	10 %
4	Lighting and miscellaneous	5 %
	TOTAL	100%

NATURAL GAS

1	Natural gas glass making furnaces	50 %
2	Natural gas glass annealing furnaces	30 %
3	Space heating boilers	15 %
4	Hand-blown glass molding flames	5 %
	TOTAL	100%

3.3.3 *Fuel Costs*

Typically, the percentage of production costs comprised of energy determines how beneficial energy conservation is Since the break up of the Former Soviet Union in 1991, energy prices have been increasing toward world prices As seen in *Table 3 5*, energy costs have become a large part of production costs In 1994, the costs were still only 30% of world energy prices Given that the prices for energy will continue to climb toward world values, energy conservation will play a major role in the cost of production

Table 3.5 Energy Costs as a Percentage of Total Production Costs

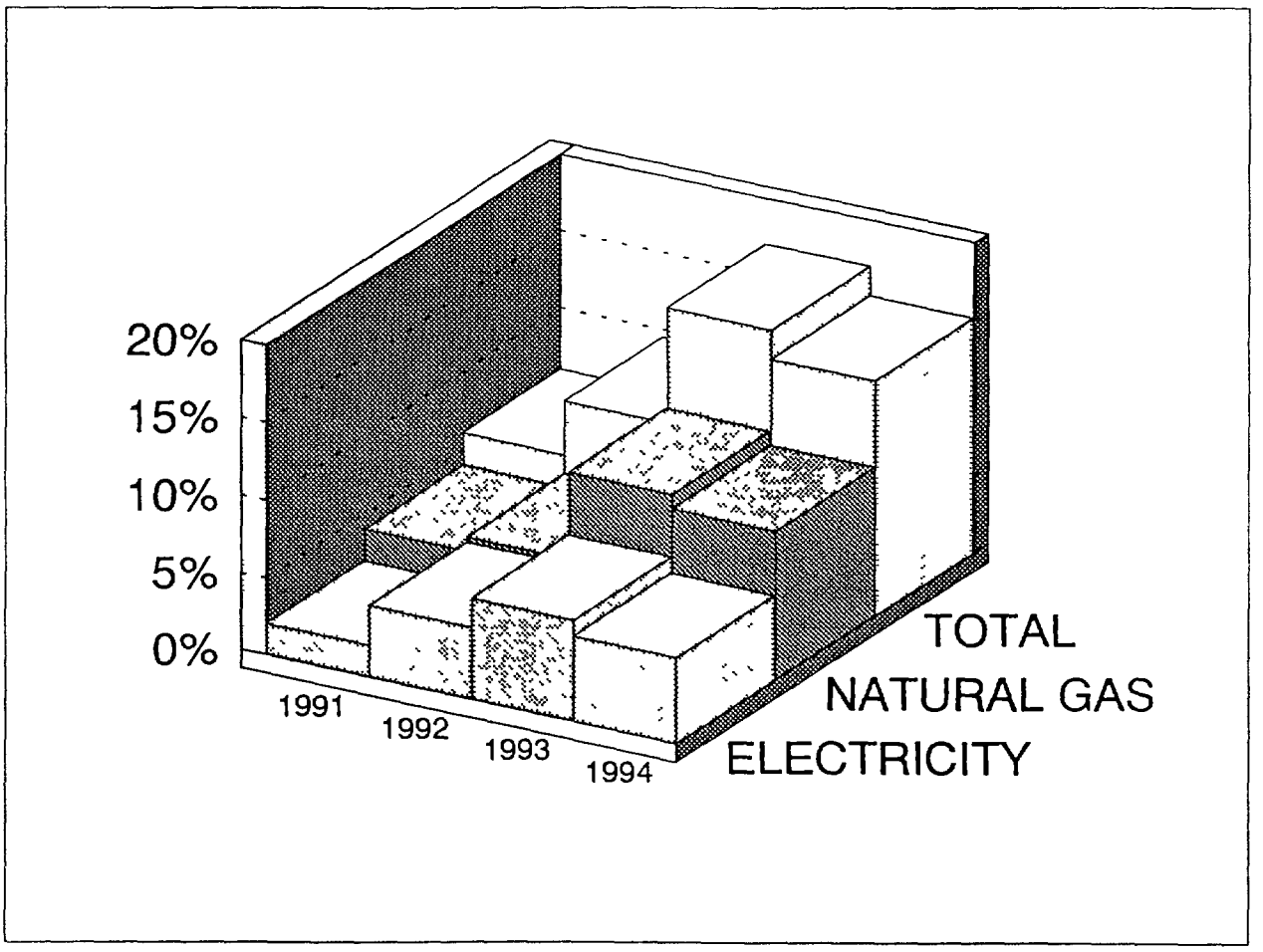
TYPE OF ENERGY	1991	1992	1993	1994
NATURAL GAS	4 0	4 9	10 5	9 6
ELECTRICITY	2 0	4 6	6 5	5 5
TOTALS	6 0	9 5	17 0	15 1

Electricity costs during 1994 averaged $0 014 per kWh Billings are based on both demand and kWh costs For each month demand is nominated by the plant energy manager The plant pays a demand charge, but since it was perceived as insignificant, none of the plant staff were able to quantify it Typically, demand charges are about 10% of the average cost per kWh in the FSU Although Ukraine's electrical generation is currently in surplus, the fuel to operate the generation stations is limited There is speculation that demand charges will be eliminated in the near future

Natural gas is supplied by the local gas company Kievgas Gas is sold by the cubic meter and has 90% of the typical heat value found in U S natural gas The cost was $ 0 022 per m^3 or $0 69 per MMBtu in 1994 This is about 17% of the world value for natural gas[3]

[3] See world energy prices in appendix "D"

Figure 3.1 Energy Costs as a % of Production Cost – 1991 - 1994



4.0 SYSTEMS AUDITED – SHORT-TERM RECOMMENDATIONS

4.1 ECO #1 - Glass Furnace Combustion Air Control

To produce molten crystal glass, white sand and lead oxide are heated to 1600 degrees Celsius The supply of this heat comes from either electricity or natural gas The plant has two natural gas fueled glass furnaces, Stove #1 and Stove #3 Plant staff worked with the audit team to monitor the combustion process of these two furnaces (see Appendix B, photograph #3) They found significant amounts of excess air present in the exhaust stack gases This means more air than necessary is being added to the combustion process, resulting in reduced fuel utilization Excess air dilutes the temperature of the combustion process, which reduces the amount of heat transferred into the glass The net result is that more fuel is necessary to complete the job

The solution to this situation is simple reduce the amount of air introduced into the furnaces Determining how much air can be removed requires monitoring the exhaust stack gases To do this, furnace operators must have a combustion analyzer Using the auditors' combustion analyzer, furnace operators were able to improve the furnace efficiency about 4% by closing dampers (see Appendix B, photograph #4) After closing inlet-air dampers, there was still excess air Future improvement to the damper system will allow additional savings

It is recommended to provide a combustion analyzer for each gas stove to routinely monitor and adjust the excess air supplied Implementation of this measure will save 255,148 m^3 of natural gas per year and will pay off the investment in 0 43 years at world energy prices, and 2 49 years at present local natural gas prices (See Appendix A, ECO #1 for details of this measure)

4.2 ECO #2 - Ventilation Fan Energy Efficient Motors Replacement

Ten fans are installed at Shop #1 to supply fresh air and cooling for the glass workers Seven of the fans are presently in operation (see Appendix B, photograph #5) The fan motors are the second largest consumer of electricity at the plant site The standard efficiency motors used for this application were almost double the size necessary for the application Oversized motors operate less efficiently than motors properly sized

It is recommended to install two high-efficiency motors of proper size Efficiency gains of 9% are expected for the higher efficiency motors, in addition to savings that will be seen due to appropriate sizing

Savings of 30,400 kWh per year are estimated for this project The investment of $2,320 will reach payback in 1 2 years based on world prices and in 5 45 years at local energy prices (See Appendix A, ECO #2 for details of this measure)

4.3 ECO #3 - Glass Reheating Stove Stack Heat Recovery

The glass-making process requires high temperatures which result in a large amount of heat being released into exhaust stacks It is desirable to recover a portion of this heat for other use in the plant Utilizing this waste heat will reduce natural gas consumption in other areas Heat recovery has a very large potential for reducing the plant's monthly energy costs

To perform heat recovery, there must be a source to use the heat The plant uses heated water to heat ventilation air and offices during seven winter months, the recovered heat will be used to supply a portion of this water heating

Installation of the heat recovery unit on the header of the glass reheating stoves would save 173,685 m^3 of natural gas per year The investment required to implement this recommendation would achieve payback in 1 02 years at world energy prices and in 5 91 years at local energy prices (See Appendix A, ECO #3 for details of this measure)

4.4 ECO #4 - Glass Annealing Oven Infiltration Reduction

Glass annealing ovens are used to reheat molded glass pieces that have cooled quickly, causing residual stresses within the piece If not annealed, the object is at great risk of breaking, even under normal handling The glass pieces are placed in a sand filled oven which is heated to just below the melting point of the glass The oven is then shut down and allowed to cool slowly over a period of eight hours This eliminates internal stress in the glassware

The ovens are simultaneously heated and loaded over a period of eight hours Because the loading doors are kept, energy is lost (see Appendix B, photograph #7) Large amounts of cool air are pulled from the room into the heated oven and up the exhaust stack The result of this is that even more natural gas is required to perform the required amount of heating

It is recommended to modify operational procedures by allowing the loading door to close when not loading the oven This will eliminate the intake of excess air Combustion analyzers, like those recommended in ECO #1, can be used to ensure a sufficient air supply for the burning process

This recommendation requires only a procedural change for implementation. It is estimated it will save 53,460 m^3 of natural gas per year Since no equipment is necessary for implementation, the project payback will be immediate (See Appendix A, ECO #4 for details of this measure)

4.5 ECO #5 - Molten Glass-Holding Furnace Combustion Efficiency

After molten glass is made, it must be kept warm until shaped A venturi-style burner is used to burn natural gas and maintain molten glass temperature (see Appendix B, photograph #6) Since the molten glass temperature is about 1500° Celsius, a significant portion of the combustion

gases' heat value is not transferred to the glass This results in high stack gas losses Capturing and using this lost heat to preheat combustion air will increase combustion efficiency by about 3%

In addition, the burners do not presently control the amount of air which is fed into the process (see Appendix B, photograph #6) Excess air will cool the flame temperature and further reduce heat transfer to the glass The recommended measure also controls the air-fuel mix to optimize efficiency and flame temperature

Because existing burners operate continuously, this measure will save 137,532 m^3 of natural gas per year The investment for new burners will achieve payback in 1 14 years using world energy costs and in 6 61 years, using local energy prices (See Appendix A, ECO #5 for details of this measure)

4.6 ECO #6 - Energy Management Program Enhancement

Plant management is aware of the benefits associated with energy efficiency, but there is no equipment to quantify the financial impacts of energy-saving measures In most cases, the ECOs require little investment, but will have great reward For measures which require an investment, prioritization against plant operational improvements will be based on the financial impacts of each opportunity Presently, production is always considered to be a much better use of financial resources because there is no way to quantify energy savings If plant management had equipment to identify and quantify energy opportunities, it would be possible to enhance the energy management program

Equipment which would be beneficial in this facility include

- 1 non-contact ultrasonic flow meter
- 1 non-contact temperature measuring device
- 1 three-phase electrical meter with logging and down-loading capability
- 1 hot wire anemometer
- 1 laptop computer
- 1 laser printer
- Energy management reference books

Using this equipment to quantify energy consumption and potential savings, the plant will be able to reduce energy consumption and track the savings Successful energy management typically requires programs to create energy awareness and systematic plant evaluations to identify no-cost/low-cost energy saving opportunities

Given the size of the plant, it is estimated that an annual savings of 5% can be achieved by using this equipment This would pay back the investments costs in 1 26 years at local energy prices and in three months at world energy prices (See Appendix A, ECO # 6 for details of this measure)

Facility energy management is traditionally felt to be the responsibility of those holding the title of Energy Manager In large plants, this task is similar to that of the Safety Manager The Energy Manager must promote energy conservation awareness to all end-users of energy The end-users must be responsible for finding the most efficient way to utilize energy in their work areas

The responsibility of the Energy Management Department is to work with plant personnel to

- **Educate** all plant personnel on energy use awareness
- **Motivate** all plant personnel to find energy conservation opportunities in their work areas
- **Reward** all plant personnel for identifying potential energy conservation opportunities
- **Quantify** each conservation opportunity potential savings and investment payback
- **Plan and update** a rolling 5-year energy management strategy to implement conservation
- **Solicit** funding for energy conservation projects
- **Implement** conservation opportunities where funded or no cost
- **Follow-up** after implementation and quantify actual savings
- **Advertise** successful energy conservation projects and lessons learned
- **Replicate** successful conservation projects to all parts of the plant

5.0 SYSTEMS AUDITED – LONG-TERM RECOMMENDATIONS

The largest potential for energy saving in this facility is in the area of fuel combustion (e g , glass furnaces, annealing ovens, gas burners) Lacking instrumentation to adjust the air-fuel mixture, fuel is burned in an inefficient manner The amount of air passing through all burners significantly exceeds that required for optimum combustion Air which is not used for combustion only cools the flame temperature With a lower flame temperature, less of the fuel's heat is transferred into the process and more is wasted up the exhaust stack

In addition, the plant produces large amounts of high-grade waste heat which could be used within the plant, as well as in neighboring facilities Flue discharge temperatures are 660°F and more Flue gas temperatures of 1,920°F were measured in exhaust stacks This occurs due to the high temperature required before heat begins transferring into molten glass Below are several long range ECOs that deserve further investigation

5.1 Improved Thermal Insulation

Improving stove and oven thermal insulation will reduce energy consumption and increase safety in the plant Temperatures of all oven and furnace walls should be measured using non-contact infrared temperature measurement Where the temperature exceeds 60°C (140° F), additional insulation should be applied Such measures will not only reduce the energy consumed by the ovens and stoves, but will also decrease the power consumed by cooling fan motors

5.2 Reduce Furnace and Stove Air

Reducing air infiltration into the main gas glass furnaces #1 and #2, annealing stoves, and satellite stoves will reduce the amount of fuel needed to heat these areas This measure will not only reduce gas consumption for heating unused air, but will also decrease power consumption of the ventilation system motors

5.3 Increase Plant Heat Recovery

Heat recovery from flue gas discharge has great potential in this plant The temperatures of flue gas discharge from gas furnaces and stoves ranges from 350°C to 1050°C (660° F to 1920° F) The best way to utilize such high potential heat is to install a small cogeneration unit Unlike space heating, cogeneration can be utilized during both the heating and non-heating seasons The plant has unused floor space which could house a cogeneration installation

5.4 Reduce Heat Transferred to Work Areas

Almost one-half of the electricity used in the plant is used for cooling and ventilation Insulating piping and stove walls near work areas will reduce the amount of cooling required, and electrical use could be significantly reduced

5.5 Combine Ventilation Supply Ducts

Combining the cool air ventilation ducts will reduce the number of motors in operation and increase the loads on the motors that are presently used The existing fan motors are presently under-loaded, reducing their efficiency By combining ducts, motors will be fully loaded, and unnecessary fan motors could be shut down Future insulation of ducts and heating walls around work areas will lower cooling air requirements, which will further reduce the number of motors necessary

5.6 Insulate Cooling Air Ducts

Uninsulted cooling air ducts run through the very warm ceilings of the plant Insulating these ducts will reduce the volume of air necessary to cool the workers Measurements were taken on the movement of cooling air to work areas The auditors found that system of air delivery is not properly adjusted the area closest to the fan received the highest volume of the coolest air As the air traveled through the plant, the volume decreased while the temperature increased

6.0 TRAINING ACCOMPLISHED

An objective of this project was to transfer information and hands-on training of energy auditing techniques to local technical personnel This was to allow them to continue auditing and energy efficiency activities after the foreign consultants completed their brief visit

6.1 Local Engineer

The local engineer, Peter Garkoun, is an experienced staff person from the local electrical utility His academic background is in electrical engineering His previous experience includes work with the energy inspection agency Energonadzor He is familiar with energy conservation techniques and metering and was able to benefit from interactions with the auditors during the audit His activities during this audit included

- Discussion with plant energy management staff of the purposes of the audit and the anticipated results
- Participation in setting up the audit plan and itinerary
- Participation in obtaining plant energy consumption history
- One-on-one training with audit equipment operation and potential uses (see audit equipment list in Appendix G)
- Participation in conducting the audit to identify potential conservation measures
- Hands-on utilization of audit equipment to quantify potential energy savings
- Discussions with plant staff to determine feasibility of conservation measures
- Participation in final "report out" meeting with plant Chief Engineer and Shop Managers
- A review of the format and function of final report content
- Discussion of similarities and differences of audits based on plant size, type, attitude, and funding availability

6.2 Plant Staff

Energy management personnel and staff from the technology department participated in the energy audit of the facility As part of the plant audit, plant personnel took part in

- Discussion of audit purpose and anticipated results
- Setting up the audit plan and itinerary
- One-on-one training with audit equipment operation and potential uses (see audit equipment list in Appendix G)
- Conducting the audit to identify potential conservation measures,
- Hands-on utilization of audit equipment to quantify potential energy savings
- Discussions of typical energy management practices is the U S
- Final "report out" meeting with plant Chief Engineer and Shop Managers

7.0 IMPACT OF ENERGY CONSERVATION OPPORTUNITIES (ECOs)

Energy Savings

In 1994, this factory consumed 16 9 million kWh of electricity and 13,589,000 m^3 of natural gas If the recommended measures are implemented, an estimated 873,162 kWh of electricity and 1,299,275 m^3 of natural gas will be saved each year This would account for an 8 2 % energy reduction for the plant

Financial Benefits

The plant is reported to be self-sufficient and not subsidized by the State Energy costs were 15% of production costs in 1994, despite the cost of energy being only 30% of world prices As energy prices increase to world levels, energy costs as a percentage of production costs will greatly increase The only way to keep production prices competitive is through energy conservation If implemented, this reports recommendations are estimated to reduce the annual cost of energy (in world prices) by $221,104 or by 7 9% using 1994 consumption figures

Effect on Production Capacity

None of the recommendations in this report will hinder production capacity In times of rationed energy resources, the measures cited in this report will increase the amount of production per unit of fuel available

Effect on Product Quality

A first requirement of energy conservation is that the actions taken will not negatively effect product quality It is hoped that a side benefit of the metering equipment specified will be better process control which could lead to improved product quality

Effect on Working Conditions

A large amount of heat is given off in the plant environment during the glass making process Insulation and capture of excess process heat will improve working conditions during hot summer months

8.0 MONITORING

It is important to follow-up with the implementations to determine actual saving achieved from the investments To accomplish this, the local engineer who worked with the audit team could be used to track implementation saving The energy consumption before and after implementation should be compared In addition, production output should be linked with this consumption The metering equipment specified for the energy management program can be used to quantify savings *Figures 8 1 – 8. 6* are forms used to collect necessary data and to quantify the energy saving achieved

ECO-01 GLASS FURNACES #1 & #3 – COMBUSTION AIR CONTROL
Combustion efficiency tests can be taken with the specified combustion analyzer, before and after tuning, at daily intervals during initial implementation A high-temperatures probe can be inserted into the stack during adjustment Measurements for one or two weeks before and after implementation will be enough to make a judgment on energy savings Total gas consumption during the each of these periods should be obtained and the amount of produced glass also quantified The amount of energy spent per unit of output (m^3 of gas per metric ton of glass) is the best index of achieved energy savings

ECO-02 VENTILATION FANS ENERGY EFFICIENT MOTORS REPLACEMENT
Two energy-efficient motors will replace two existing motors which drive ventilation fans Power consumption can be measured daily for one week before implementation and one week after

ECO-03 STACK HEAT RECOVERY FROM GLASS REHEATING STOVE
The following parameters can be measured daily for two weeks after ECO implementation

1 Flow rate of heating water passing through economizer
2 Temperatures of water before and after economizer

Heat recoveredfrom the discharge of flue gas during this period can be calculated The gas saving can be evaluated, due to the fact that generation of this heat is avoided at the local boiler house

ECO-04 GLASS ANNEALING OVEN INFILTRATION REDUCTION
Combustion efficiency tests can be taken with the specified combustion analyzer, before and after tuning, at daily intervals during initial implementation A high-temperature probe can be inserted into the stack while adjusting to the combustion process Measurements for two weeks before and after implementation will be enough to make a judgment on energy savings Total gas consumption during each of these measurement periods has to be obtained to verify energy savings

ECO-05 MOLTEN GLASS HOLDING FURNACE EFFICIENCY IMPROVEMENT
Combustion efficiency tests can be taken with the specified combustion analyzer, before and after tuning, at daily intervals during initial implementation A high-temperature probe can be inserted into the stack during the adjustment of combustion air Measurements for two weeks before and

after implementation will be enough to make a judgment on energy savings Total gas consumption during the each of these measurement periods should be obtained to verify obtained savings

ECO-06 ENERGY MANAGEMENT PROGRAM ENHANCEMENT

Each measure implemented as a result of this equipment will be recorded and monitored by plant staff A continuous energy savings total can be kept by plant energy management staff

After projects are implemented in this facility, it is important to follow-up with the implementations to determine actual savings achieved from the investments To accomplish this, the local engineer who worked with the audit team could be used to track implementation savings Using metering on the equipment specified, the savings can be quantified

9. 0 Results of Follow-up Visit

9.1 Objectives of Visit

The objectives of the July 1997 equipment follow-up visit were to

- Verify arrival of demonstration energy efficiency equipment
- Inspect delivered energy efficiency equipment for damage and completeness
- Provide hands-on training on equipment use to facility staff where needed
- Determine facility operational changes since 1995 energy audit
- Identify follow-up necessary to resolve equipment difficulties
- Assess energy conservation achievements in response to the 1995 audit

The original program design allowed time for the plant to implement recommended energy efficiency measures and begin monitoring the results prior to the equipment follow-up visit The actual follow-up visit occurred after the plant received its first group of equipment, but prior to some equipment being cleared from customs

9.2 Main Energy Conservation Opportunities Identified in 1995

Of the Energy Conservation Opportunities (ECOs) identified during the 1995 plant energy audit, the following ECOs were accepted for implementation by the plant

ECO #1.	Gas fired, glass furnace combustion air control
ECO #2	Ventilation fan energy efficient motor replacements
ECO #4	Glass annealing oven infiltration reduction
ECO #5	Molten glass holding furnace burner efficiency improvement
ECO #6	Energy management program enhancement

9.3 Status of Plant During July 1997 Visit

In the two-year period between visits, the glass plant had significantly changed its operation level During the initial plant energy audit, four glass-making furnaces were in operation These consisted of two electric and two natural gas-fired furnaces

During the visit in July of 1997, the plant had completed the privatization process with the bulk of stock owned by plant employees The plant manufactures products for the Ukraine marketplace As the Ukraine economy has declined, so has the market for the plant's goods Plant staff cited high export duties as the reason for inability to compete in the markets outside Ukraine The plant has considered targeting its products to the Kiev tourist industry, although implementation has not yet occurred. As a result of the reduced market, plant production has

been confined to one glass-making furnace

9.4 Accomplishments During Visit

ECO #1 GLASS FURNACE COMBUSTION AIR CONTROL (Gas-fired)
The plant has reduced the number of operating glass-making furnaces from four to one The one furnace in operation generates heat using electricity as opposed to natural gas. The plant chose an electric furnace because of production factors and a greater ability to control furnace output

The two combustion analyzers supplied by the project are intended to improve combustion efficiency of the gas-fired, glass-making furnaces Since the gas furnaces are currently not in operation, the combustion analyzers were demonstrated on two boilers which were in operation

Plant process technical staff, boiler house staff, and the plant instrumentation specialist participated in classroom instruction and field operation of the combustion analyzers on two separate boilers in the boiler house (see photo KGP - 2) Plant staff made air supply adjustments to the boilers while using the combustion analyzer to monitor exhaust products. The personnel who received training gained confidence in the operation, basic functions, and benefits of the combustion analyzer

ECO #2 VENTILATION FAN ENERGY EFFICIENCY MOTOR REPLACEMENT
The two high-efficiency motors required for implementation of this ECO had not cleared customs at the time of the plant visit Plant staff were quite confident in their ability to change over the fan motors once they clear customs Energy consumption before and after motor changeover will be quantified using the power meter provided in the equipment package. The hot wire anemometer supplied in the equipment package can also be used to determine fan flow rates before and after the motor changeover Ventilation fans make up 40% of the plant's electrical load See *Figure 8 3* "ECO - 2 Monitoring Data Sheet" to quantify results of implementation

ECO #4 GLASS ANNEALING OVEN INFILTRATION REDUCTION
Plant staff reported that they had implemented the practice of keeping the annealing oven doors closed whenever possible Individual natural gas metering is not available to verify project savings Since no capital investment was required to implement this measure, the payback is immediate

The plant can quantify the savings for this ECO by measuring the combustion efficiency in the stack with the doors closed and repeat the measurement again with the doors open A time study can produce the amount of closed-door time possible during a typical loading period Together, the amount of gas savings can be determined See *Figure 8 5* "ECO - 4 Monitoring Data Sheet" to quantify savings achieved by implementation.

ECO #5. MOLTEN GLASS HOLDING FURNACE BURNER EFFICIENCY IMPROVEMENT

The new burners were in customs at the time of the plant visit When they are received, the plant should work with the local combustion specialist that assists them with their existing burner needs. This is required to assure proper installation and startup of the burners Burner manufacturer contact information to reach technical support is provided along with the burners The manufacturer's technical support person should be contacted to verify correct installation prior to start-up See *Figure 8 6* "ECO - 5 Monitoring Data Sheet" to quantify savings for this measure when installation is completed The combustion analyzers supplied to the plant will provide measurements for this monitoring

Minimizing air infiltration into the holding furnace will maximize efficiency Plant process staff should work to implement methods to close off access ports when not in use. This will both minimize energy consumption and increase worker comfort by reducing the amount of heat which is radiated into the working area.

ECO #6 ENERGY MANAGEMENT PROGRAM ENHANCEMENT

Rustrak Ranger - Recording Electric Power Meter

This meter will be very valuable to the plant for quantifying existing electrical loads in order to compare the results of modifications intended to save energy The review team worked with specialists from the plant electrical shop to instruct them regarding setup and installation procedures for the meter. Power monitoring was completed on a motor which had just been repaired in the plant electrical shop (see photo KGP -3). In addition, the meter was set up on the electrically heated glass furnace in operation

A software program is provided with the meter to facilitate both initial setup, and long-term monitoring analysis The vendor program is written in English only This will require plant staff to work with translators to identify the procedure for using the software. This meter will be used to monitor the energy efficiency savings of the high-efficiency motors to be retrofitted on the existing plant ventilation system

Peek Model ISTT-P Ultrasonic (Transit Time) Flow Meter

This meter will be used to quantify plant heating water consumption The hot water is produced in the plant boiler house and is used for space heating, domestic washing, process cleaning It is also sold to a neighboring business

Given the large amount of waste heat available in the glass plant, this meter can help the plant identify areas in which plant water heating supply can be generated through waste heat recovery The meter can also quantify the volume of heated water supplied to the neighboring plant This supply may also be generated using plant waste heat

Detailed instruction on meter application and installation was covered during the plant visit A field installation of the meter was applied at the plant's main water service entrance This spot was chosen because of the ability to compare readings of the portable meter with the permanently installed plant water meter. Unfortunately, the ultrasonic meter consistently reported that a signal was not received After significant trouble shooting, including contact with the manufacturer, it was determined that the meter should be returned to the manufacturer for diagnosis of the problem

Air Speed Meter (Anemometer) Kurz Model 444-M-HT

The meter was used after some basic instruction Plant technical staff used the meter to monitor air flows from a window air conditioner and from plant ventilation supply grille (see photo KGP-5). Plant cooling / ventilation air is a major electricity consumer in the plant This meter will allow the plant to provide sufficient air flow in work areas of the plant without oversupplying an area In the winter, the ventilation air is tempered with hot water This is an additional energy investment into the air. With the air speed meter, the plant technical staff can balance the cooling / ventilation air supplies throughout the plant

Through reduction of glass furnace heat radiation into the workers' spaces, the plant can reduce cooling/ventilation air requirements This would call for heat shields to be installed in work areas. Mechanisms would be necessary to automatically move the heat shield when access to the molten glass supply is needed.

Infrared Thermometer (Mid-range) Mikron M90B

This meter is intended to identify heat loss in pipe and refractory insulation. The meter requires only basic instruction to be mastered by a first-time user After basic instruction as to the meter's features, various surfaces in the production area were measured until confidence was gained in use of the meter.

During the plant visit in 1995, plant technical staff utilized the auditing team's infrared thermometer to make assessments of furnace refractory condition throughout the plant Discussions during the follow-up visit revealed that refractory upgrade had taken place in several areas of the plant as a result of the temperature survey. Before and after records were not available

Desktop Computer (HP Vectra) and Laser Printer (HP LaserJet IV+)

Computers have become a necessary part of energy management They provide a means to set up and retrieve data from monitoring equipment in addition to providing the capability to perform complex estimation and track calculations which would otherwise be ignored In addition, they have the capability of creating attention-getting reports which lend credibility when promoting energy savings projects

The computer and printer had been set up and tested by plant staff prior to our visit The computer was originally received with the English version of Windows 95. The plant had hired a local computer specialist to install the Russian version of Windows 95 along with the word processing software "WORD" (see photo KGP - 4) The plant also has plans to install a spreadsheet program, such as "EXCEL" Prior to our visit, the plant had created and printed several documents.

This computer will also be necessary to install software which is used to facilitate setup and allow output of several pieces of the equipment provided to the plant The software provided with the monitoring equipment is only available in English. This is currently a barrier because of the limited English skills of plant technical staff. Despite this, plant technical staff was confident that they could follow the software manuals which had been translated from English to Russian

The pieces of equipment with computer-assisted setup and downloading capability included the combustion analyzer, electrical power meter, and ultrasonic flow meter

The plant's energy management program should be led by one person, and specialized plant staff assigned to the program should be responsible for carrying out energy-saving initiatives. Currently, the plant has a person on staff designated as the plant energy manager. Traditionally, this position had been involved primarily with the procurement of energy supplies It is recommended that this person be designated to lead programs to increase plant energy efficiency

During difficult economic times, energy efficiency becomes even more important at the plant because when cost of operation must be cut, it is more desirable to cut energy costs as opposed to reducing labor costs through force reductions

The Chief Engineer is encouraged to develop an initiative to minimize all wasted energy. This can be carried out through the plant energy manager The facility now has the equipment to quantify the amount of energy used in the plant in addition to measuring the energy consumption change when modifications are made to equipment and plant operating procedures

The preceding report provides ample energy cost reduction recommendations to enhance the existing energy management program. In addition, energy management books were provided to the plant along with the energy monitoring tools. Utilizing the equipment and resources provided will reduce energy expenditures in the plant with minimal capital investments

9.5 Equipment Provided to Plant to Accomplish Identified ECOs

Below is a list of equipment supplied to the Kiev Glass Factory to implement ECOs supported by plant management· (see photo KGP - 1)

	Quantity	Equipment
ECO #1	(2) Two	Enerac 2000 combustion analyzers
ECO #2	(2) Two	Magnetek 25 Hp high-efficiency motors
ECO #4	(0) None	No equipment needed
ECO #5	(2) Two	Natural gas burners, boiler room specialties LNIC-G-30
ECO #6	(1) One	Ultrasonic, transit time flow meter by Peek Meas., ISTT-P
	(1) One	Electric power meter, Rustrak RR-1233A-2-0-0
	(1) One	Anemometer - Kurz 444-M-HT (air speed, temperature)
	(1) One	Desktop computer, HP Vectra
	Set	Books (energy management, $250 total cost)
	(1) One	Infrared thermometer mid-range, Mikron M90B

9.6 Work Required to Complete Implementation

Peek Model ISTT-P Ultrasonic (Transit Time) Flow Meter Operation
As discussed above, the Ultrasonic flow meter did not operate properly during the plant visit It is necessary to ship the meter and all support equipment to the manufacturer for diagnosis of the problem If the meter is determined to be operational upon receipt by the manufacturer, a determination must be made by the manufacturer of the probable cause of malfunction under field conditions. In addition, a calibration block was not present in the support equipment delivered with the ultrasonic meter This piece of equipment must be obtained and delivered to the plant Presence of the calibration block may have assisted the trouble-shooting process in the field, although manufacturer technical support reported that this would not be the cause of the meter's reporting of "no signal detected " The Peek / Polysonics contact person is Mr Santos Martinez at (281) 879-3700

Rustrak Ranger, Model 1233 - Recording Electric Power Meter Equipment Correction
Provide three pairs, or a total of six (6) current transformer cord adapters for 0 to 1000 Amp (1 amp = 1 mV) current transformers included in the set The connection from the meter itself is a male, and the connections on each current transformer cord are also male The Rustrak contact person is Mr Fred Gineki at (401) 884-6800 ext 215

9.7 Lessons Learned

Several lessons learned are discussed in this section to benefit future projects of similar nature.

When available, all software supplied should be in a local language This could most easily be done with local procurement of software

All monitoring equipment should be field tested in the U.S by someone other than the manufacturer. This would include testing of the equipment in addition to verification that all support equipment is present.

All monitoring equipment should be provided with a description of the technique and support equipment necessary to calibrate the instrument

For combustion retrofit equipment, funding should be provided to hire a local combustion specialist for equipment compatibility verification, installation, start-up, and to perform local certification. Combustion equipment should be purchased on a sole source basis to ensure the equipment is compatible with the intended installation

9.8 Photographs Taken During July 1997 Visit

PHOTO KGP-1 Energy Efficiency Monitoring Equipment Received

PHOTO KGP-2 Plant Technical Staff and Project Representatives During Combustion Testing

PHOTO KGP-3: Motor Testing with Rustrak Ranger Power Meter

PHOTO KGP-4: Computer Software Training with Plant Staff

PHOTO KGP-5: Ventilation Air Supply Measurement with Kurz Anemometer

9.9 Plant Contacts Made During July 1997 Follow-up Visit

Plant Address
Ukraine, 252039 Kiev
Krasnozvezdny Prospect 119
Kiev Artistic Glass Factory

Telephone: (380-44) 264-6111 or 267-7370
Fax (380-44) 264-7046

Mr Victor T. Tchernetsky
Chief Engineer

Ms Larissa Ya Matveyhchuk
Chief Process Engineer

Mr Oleg Veceliovich Rusvnik
Deputy Director of Plant

Mr Nickoli Andreyvich Bashtovoy
Deputy Chief of Power Plant (boiler house)

Mr Yaruslav Nikolayevich Burgardt
Chief of Power Plant (boiler house)

Mr Stephan Ivanovich Yazupol
Plant Controls Technician

Mr. Stanislav Appoliarievich Sikurskig
Plant Chief Electrician

Mr Leonid T. Prokopov
Deputy Chief of Electrical Shop

Figure 8.1 ECO - 1 Monitoring Data Sheet

GLASS FURNACE # 1 COMBUSTION - EXCESS AIR CONTROL

BEFORE IMPLEMENTATION					AFTER IMPLEMENTATION					
Data	Temperature of Ambient Air, °C	Excess of Air, %	Stack Temperature °C	Combustion Efficiency, %	Data	Temperature of Ambient Air, °C	Excess of Air, %	Stack Temperature °C	Combustion Efficiency, %	Changes in Efficiency %
Gas consumption per period, m^3 -					Gas consumption per period, m^3 -					Changes in Consumption m^3

Figure 8.2 ECO - 1 Monitoring Data Sheet

GLASS FURNACE # 3 COMBUSTION - EXCESS AIR CONTROL

BEFORE IMPLEMENTATION					AFTER IMPLEMENTATION					
Data	Temperature of Ambient Air, °C	Excess of Air, %	Stack Temperature °C	Combustion Efficiency, %	Data	Temperature of Ambient Air, °C	Excess of Air, %	Stack Temperature °C	Combustion Efficiency, %	Changes in Efficiency %
Gas consumption per period, m^3 -					Gas consumption per period, m^3 -					Changes in Consumption m^3

Figure 8.3 ECO - 2 Monitoring Data Sheet

VENTILATION FAN ENERGY-EFFICIENT MOTOR REPLACEMENT (FAN #)

BEFORE IMPLEMENTATION			AFTER IMPLEMENTATION			
Data	Average Daily Load, kW	Daily Consumption, kWh	Data	Average Daily Load, kW	Daily Consumption, kWh	Changes in Consumption kWh
Total power consumption per period, kWh -			Total power consumption per period, kWh -			

Figure 8.4 ECO - 3 Monitoring Data Sheet

STACK HEAT RECOVERY FROM GLASS REHEATING STOVE

	Flow Rate	Temperature of Water		
DATA	of Heating Water, m^3/hr	Before Economizer, °C	After Economizer, °C	Recovered Heat, Gcal/day

Recovered Heat Total, Gcal/week

Figure 8.5 ECO - 4 Monitoring Data Sheet

GLASS ANNEALING FURNACE INFILTRATION REDUCTION

BEFORE IMPLEMENTATION					AFTER IMPLEMENTATION					
Data	Temperature of Ambient Air, °C	Excess of Air, %	Stack Temperature °C	Combustion Efficiency, %	Data	Temperature of Ambient Air, °C	Excess of Air, %	Stack Temperature °C	Combustion Efficiency, %	Changes in Efficiency %
Gas consumption per period, m^3 -					Gas consumption per period, m^3 -					Changes in Consumption m^3

Figure 8.6 ECO - 5 Monitoring Data Sheet

MOLTING GLASS HOLDING FURNACE EFFICIENCY IMPROVEMENT

BEFORE IMPLEMENTATION					AFTER IMPLEMENTATION					
Data	Temperature of Ambient Air, °C	Excess of Air, %	Stack Temperature °C	Combustion Efficiency, %	Data	Temperature of Ambient Air, °C	Excess of Air, %	Stack Temperature °C	Combustion Efficiency, %	Changes in Efficiency %
Gas consumption per period, m^3 -					Gas consumption per period, m^3 -					Changes in Consumption m^3

APPENDIX A

Energy Conservation Opportunities (ECOs)
Calculation of Fuel and Fuel Cost Savings
Calculation of Implementation Costs
Specifications of Equipment to be Installed

A.1 ECO-1 COMBUSTION AIR CONTROL ON GLASS FURNACES

Description of ECO

Adjust the combustion system air-fuel ratio on numbers 1 and 3 glass furnaces to reduce the amount of excess air passing through the furnace This will improve the combustion efficiency The furnaces are used for converting crystal glass raw material to molten glass at 2,912° F

Currently excess air required for combustion ranges from 51 % at furnace # 1 to 202 % at furnace # 3 In order to adjust the air-fuel ratio for maximum efficiency, it is suggested that a combustion analyzer be purchased. This will be used for monitoring combustion in furnaces and several small annealing ovens The air-fuel ratio can be checked every other week and balanced to obtain maximum combustion efficiency This is a very simple procedure, requiring about 30 minutes The furnaces should be inspected for exterior cracks or holes where excess air may be entering the system It was found that these pathways are leaking excessively These leaks reduce the ability to optimize excess air in the combustion process Once these leaky pathways are identified and sealed, the air and fuel flow rates to the combustion chamber can be adjusted to obtain the optimum air-fuel ratio This ensures efficient combustion

Plant Information

The average gas usage by these furnaces is approximately 240 m^3/hr for furnace #1 and 270 m^3/hr for furnace #3. These values were obtained from plant staff They are based on the design and the records of consumption The furnaces are used 24 hours a day, all year, resulting in approximately 8,000 hours of annual operation (including routine maintenance downtime) The flue gas analysis results from the furnaces are attached Several observations can be made by observing this table

1) Excess air for furnace #3 significantly exceeds that of furnace #1 133% of the air was heated and discharged from this furnace even after complete shut down of the air damper An uncontrolled large opening for air entry must exist at this furnace Plant staff promised to explore where this air comes from during the next preventive maintenance shutdown This excess air explains why the temperature of the flue gas for this furnace is significantly lower than for furnace #1 large amounts of introduced cold air dilutes flue gas temperatures

2) Every 20 minutes the ducts for flue gas and combustion air switch This means that, at the beginning of this cycle, the temperature of flue gas is normally lower (and efficiency is higher) than at the end of the cycle This is due to greater amounts of heat recovered from the exhaust gas

It is possible that thetemperature of flue gas discharge could be even lower after adjustment of air-fuel ratio This is because the hotter flame temperature will transfer more heat by radiation

TABLE A.1

	Furnace # 1		Furnace # 2	
	Existing Condition	After Adjustment	Existing Condition	After Adjustment
Oxygen (%)	7 5	5 0	14 4	12 4
Carbon Dioxide (%)	7 5	8 9	3 6	4 8
Stack Temp (F)	1286	1267	599	653
Combustion Air Temperature (F)	100	100	68	68
Excess Air (%)	51	28	202	133
Combustion Efficiency (%)	62 4	66 9	67 8	72

Analysis

After adjusting the excess air quantity down, the optimum point of operation achieved was found to be 28% excess air and combustion efficiency of 66 9% for Furnace #1 and 133% and 72% respectively for Furnace #3 The annual energy savings, ES, can be calculated as follows

$$ES = A * B * (1 - \eta_{exist} / \eta_{new}) * C,$$

where

ES = Energy savings, m^3 /yr or MMBtu

A = Gas consumption rate of furnace, m^3/hr

B = Annual hours of operation of furnace, hr/yr

C = Conversion factor, 900 Btu/ ft^3 * 35 31 ft^3 / m^3 / 1000000 = 0 0318 MMBtu / m^3

η = Combustion efficiencies of furnace, %

$ES_{FURNACE\ 1}$ = 240 m^3/hr * 8000 hr /yr * (1-62 4/66 9) = 129,148 m^3/yr or
129,148 * 0 0318 = 4104 MMBtu/yr

$ES_{FURNACE\ 3}$ = 270 m^3/hr * 8000 hr /yr * (1-67 8/72) = 126,000 m^3/yr or
126,000 * 0 0318 = 4007 MMBtu/yr

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Annual Fuel Cost Savings

FURNACE #1

Local Prices
CS_L = 129,148 m^3/ 1/r * \$0 022 / m^3 = \$ 2,841/yr
World Prices
CS_W = 4104 MMBtu/yr * \$ 4 /MMBtu = \$ 16,416 /yr

FURNACE #3

Local Prices
CS_L = 126,000 m^3/yr * \$0 022 / = \$ 2,772
World Prices
CS_W = 4007 MMBtu/yr * \$ 4 /MMBtu = \$ 16,028 /yr

Implementation Cost

Provide two Bacharach model CA300NSX combustion analyzer at a cost of \$ 7,000 US each including shipping and handling

Simple Payback

At Local Prices = \$14,000/(\$2,841 + \$2,772) = 2 49 year

At World Prices = \$14,000/(\$16,416 + \$16,028) = 0 43 year

A.2 ECO-2 VENTILATION FAN ENERGY EFFICIENT MOTOR REPLACEMENT

Description of ECO

There are ten ventilation fans in the plant of which seven were operating at the time of the audit These fans supply make-up air to work stations The motors were found to be significantly under loaded In this partially loaded condition both the efficiency and the power factor drop substantially Since the motors are operated at a constant speed in this application, they can be replaced with a smaller high efficiency motor By doing this, the new motor will be more fully loaded and thus operate more efficiently The analysis is based on motors available in the US in terms of efficiencies, sizes and mounting arrangements It is recommended that the new high efficiency motor and an old existing motor be monitored using a dranetz analyzer

Plant Information

Two motors recommended to be replaced are 380V / 3 phases / 50 Hz motors rated full load capacity of 30kW, and rpm 1470 Per the plant personnel, this ventilation fan operates continuously, 24 hours a day, 365 days a year This comes to approximately 8000 hours per year when factoring in downtime

Analysis

The motor field data and energy consumption are summarized in the calculation *Table A 2* The existing motors were measured to be only 55 % loaded (16 73 kW), and so not only the motors can be replaced with an efficient one but also downsized We recommend installation of a 25 hp motors (18 65 kW) which will be 90% loaded

The existing motors efficiency was taken to be that of a standard 1800 RPM American made motor which is 89 4% Since the existing motors are approximately 15 years old, the efficiency is conservatively derated to an additional 4% lower so that the existing motor efficiency is taken as 85 4% in the energy use calculations below The new high efficiency motors will have an efficiency of 94 1% The new motors will also improve the overall plant power factor and provide additional energy savings which are not readily calculable and so have not been included in the energy savings

The total annual demand savings, DS, and energy savings, ES, which can be realized by installing one high efficiency motor, are calculated as follows

Existing motor input kW = 16 73 (see *Table A-2*)

New motor input kW = η_{std}/η_{HEM} * Existing Motor Input kW =
= 0 834/0 941 * 16 73 = 14 83 kW

DS = 16 73 - 14 83 = 1 9 kW

ES = 1 9 kW x 8000 hr /yr = 15,200 kWh/yr

Annual Cost Savings

Local Prices
CS_L = 15,200 kWh/yr * $0 014/kWh = $ 213/yr
World Prices
CS_W = 15,200 kWh/yr * $0 064/kWh = $ 973/yr

Implementation Cost

Cost, including shipping and handling -- $ US 1,160 Installation will be carried out in house

Simple Payback

At Local Prices = 1160/213 = 5 45 yr

At World Prices = 1160/973 = 1 19 yr

For two motors implementation cost will be $ 2,320 US, and power saving will be 30,400 kWh/year

Table A-2

HIGH EFFICIENCY MOTOR REPLACEMENT	
Measurements:	
Voltage Phase A, V	232
Voltage Phase B, V	232
Voltage Phase C, V	231
Current Phase A, A	40
Current Phase B, A	42
Current Phase C, A	39
Power Factor Phase A, %	55
Power Factor Phase B, %	62
Power Factor Phase C, %	62
Operating Speed, RPM	1477
Voltage Frequency, Hz	49 3
Nameplate Data:	
Rated Full Load Power, kW	30
Full Load Speed, RPM	1470
Synchronous Speed, RPM	1500
Calculations:	
Power Phase A, W	5,104 00
Power Phase B, W	6,041 28
Power Phase C, W	5,585 58
Input, kW	16 73

Table A.3

WHAT IS HIGHER EFFICIENCY WORTH?

HP @ 1800 RPM	EFFICIENCY		ANNUAL SAVINGS BALDOR SUPER-E**
	BALDOR SUPER-E (TEFC)	AVERAGE STANDARD MOTORS*	
15	92.4%	86.5%	$ 507
20	93.0	87.5	618
25	94.1	88.5	769
30	94.1	88.1	993
40	94.5	89.4	1,104
50	95.0	90.4	1,225
60	95.0	90.3	1,504
75	95.0	90.8	1,671
100	95.0	91.6	1,788
125	95.0	91.8	2,099
150	95.0	92.3	2,112
200	95.0	93.3	1,754

A.3 ECO-3 STACK HEAT RECOVERY FROM GLASS REHEATING STOVE

Description of ECO

Install an economizer in the oven stack vent in order to recover energy from the flue gas and transfer it to the heating water return main This will reduce the load on existing boilers located in the boiler house (see schematic of heat recovery economizer system) Since the recovered heat can only be used during the heating season, the economizer will be installed in a bypass vent with diverting dampers In the winter, the flue gases can be diverted through the economizer when heating is needed and vented directly the rest of the year

Plant Information

The following data was obtained from a combination of information provided by the plant personnel and measurements in the field

•	Temperature of the flue gas	1043° F
•	Input rating of the Oven	45 m^3/hr
•	Annual hours of operation (duration of a heating season)	4000 hr /yr
•	Heat content of fuel	900 Btu/ft^3
•	Average temperature of return heating water at a heating season	42°C (108° F)
•	Average temperature of supply heating water at a heating season	72°C (162° F)

Analysis

The potential annual energy savings (ES) were determined by running a computer selection for an economizer The information from the field was used to select an economizer The recovered heat is given by the temperature rise and flow requirements on the tube side

Return water in the amount of 25, 586 lb/hr (51 1 gal/min) should be passed through economizer The temperature of flue gases will be lowered to 318° F Thermal insulation should be put on the stack after the economizer to avoid condensation within flue gas The temperature of the heating water after economizer is assumed 162° F to match the heating requirements

Heat Transferred from flue gases by lowering of temperature from 1043° F to 318° F =
1,381,650 Btu/hr

ES = 1,381,650 Btu/hr * 4000 hr /yr = 5,520 MMBtu/yr or
5,520 * 1,000,000 Btu per MMBtu * 0 252 kcal per Btu / 8009 kcal per m^3
= 173,685 m^3 /yr

Some pumping energy has to be expended in the heat recovery process to override the pressure drop within economizer and piping system Required head to be maintained by pump is assumed 30 ft of water A 3/4 hp motor will drive this pump This will reduce our total energy savings as follows

Pumping energy required = 0 75 hp * 0 746 kW/hp * 4000 hr /yr = 2,238 kWh/yr

Annual Fuel Cost Savings

Local Prices

CS_L = 173,685 m^3/yr * $ 0 022/m^3 - 2238 kWh/yr * $0 014/kWh = $ 3,790/yr

World Prices

CS_W = 5,520 MMBtu/yr * $ 4/MMBtu - 2238 kWh/yr * $0 064/kWh = $ 21,937/yr

Implementation Cost

Cost, including shipping and handling -- $ 22,400 US The installation of the economizer will be done by in-house technical staff

Simple Payback

At Local Prices = $ 22,400/$3,790 = 5 91 yr

At World Prices = $ 22,400/$ 21,937 = 1 02 yr

A.4 ECO-4 GLASS ANNEALING OVEN INFILTRATION REDUCTION

Description of ECO

The oven doors on all three of the existing glass annealing ovens are kept open during loading The ovens draw in excess air through these open doors by convection This air being relatively cooler results in additional heating required by the furnace to maintain the annealing chamber temperature One way to conserve this heat is to shut the doors when items are not being placed in the oven The cracks between the oven and oven doors are probably enough to provide the required combustion air If needed, a door stop may be provided that will keep the doors from shutting completely, thereby ensuring availability of combustion air

Plant Information

The average gas usage by the three ovens is approximately 135 m^3/hr This value was obtained from plant records The ovens use gas for heating for only eight hours in a day all year around, resulting in approximately 2,640 hours of annual operation including maintenance downtime Although a port was available for taking combustion analyzer readings, it is clearly the case that the excess combustion air is uncontrolled and entering through such a large door opening that it far exceeds the required amount

Analysis

A conservative energy savings estimate of 5% was used to calculate the total energy savings for the three oven resulting from a reduction in infiltration

$$ES = A * B * N * \eta * C, \text{ where}$$

ES = Energy savings, MMBtu/yr or m^3/yr
A = Gas consumption rate of furnace, m^3/hr
B = Annual hours of operation of furnace, hr/yr
N = Number of ovens, no units
C = Conversion factor, 900 Btu/ ft^3 * 35 31 ft^3 / m^3 / 1000000 = 0 0318 MMBtu / m^3
η = Percent savings, %

$$ES = 135\ m^3/hr * 2{,}640\ hr/yr * 3 * 0\ 05 = 53{,}460\ m^3/yr \text{ or}$$
$$53{,}460 * 0\ 0318\ MMBtu / m^3 = 1{,}700\ MMBtu/yr$$

Annual Fuel Cost Savings

Local Prices
CS_L = 53,460 m^3/yr * \$0 022 / m^3 = \$ 1,176/yr
World Prices
CS_W = 1,700 MMBtu/yr * \$ 4 /MMBtu = \$ 6,800

Implementation Cost

This measure has no costs associated with except the need for the users of the annealing ovens to keep the oven doors closed whenever they are not removing or placing anything in the ovens This way the amount of savings that are eventually realized will depend on how these ovens get used

A.5 ECO #5 MOLTEN GLASS HOLDING FURNACE EFFICIENCY IMPROVEMENT

Description of ECO

The duty of this furnace is to keep molten (liquid) glass warm until it is formed in the plant Since molten glass is approximately 1500 degrees Celsius (2,732° F), it requires a flame of higher temperature before the heat will be absorbed into the glass Because of this, the temperature of the stack gases is very high The high temperature stack gases are a large source of energy loss

The burners presently used are venturi-type and are placed through large openings in the side of the furnace (see Appendix B, picture #6) This creates excessive air entering the combustion process One method to eliminate this excessive air is to replace the existing burner type with a power burner which controls the fuel and air mixture The temperatures in the stack exceeded the combustion analyzers capability It is believed that at least 80% excess air will be seen in this burning process With a power burner, the excess air could be reduced to 20% To be conservative, a 30% reduction of excess air will be used With the high stack temperatures in this process, for each 10% of excess air that is reduced, a 0 1% efficiency will be achieved (see *Figure A-1*) Reducing excess air by 30% will improve the combustion efficiency by 3%

The natural gas fuel is presently burned with air from inside the plant which is approximately 27 degrees Celsius (80° F) If the air is preheated using the heat from the exhaust stack, a portion of this heat can be recovered Typical savings for stack heat recovery are one percent efficiency for every 22 degrees Celsius (40° F) that the stack temperature is reduced

Since combustion air will be heated 67° Celsius (120° F), the stack temperature will reduce by 90% of this amount This is because air for combustion makes up a minimum of 90% of the stack gases To be conservative, a 2% efficiency improvement is estimated The burner size is estimated to be 157 m^3 / hr (5 MMBtu / hr)

Analysis

A conservative energy savings estimate of 5% was used to calculate the total energy savings

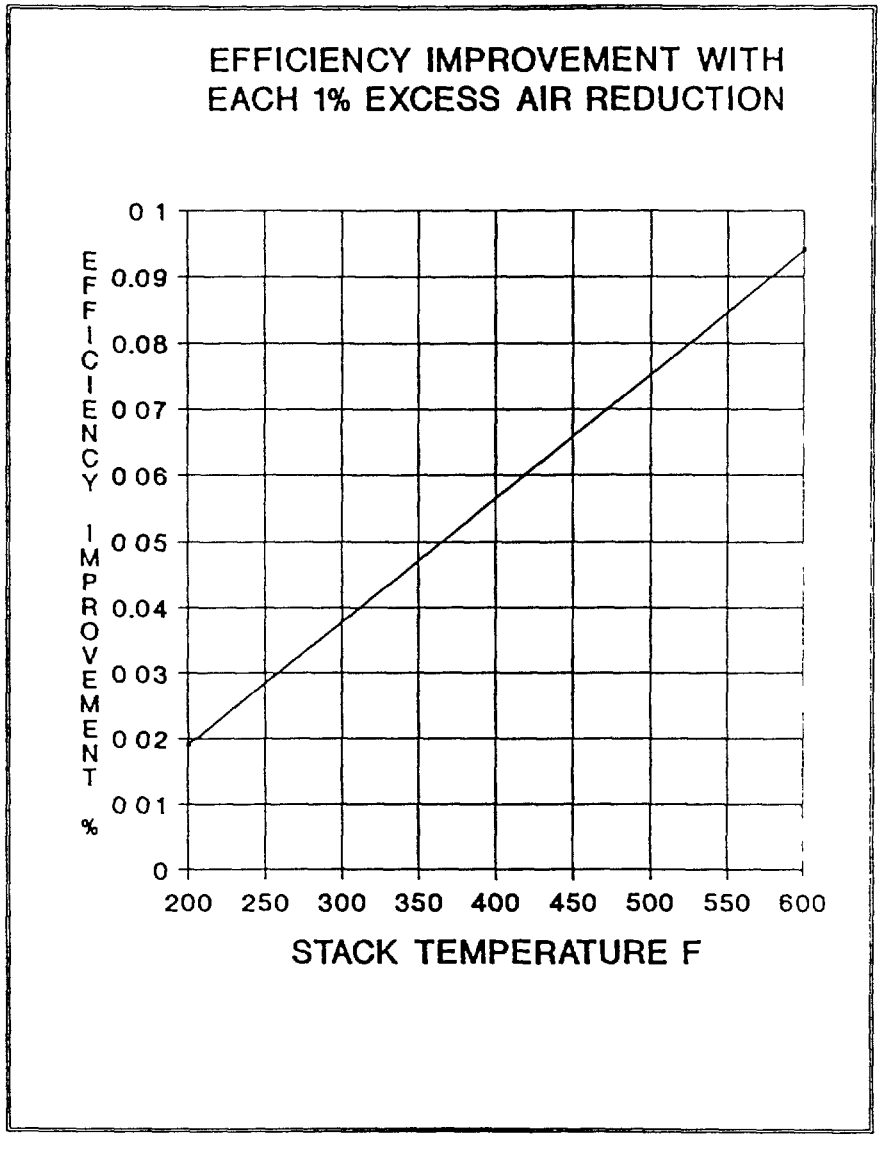
$ES = A * B * N * \eta$, where

ES = Energy savings, m^3 of natural gas/yr
A = Gas consumption rate of furnace, m^3/hr
B = Annual hours of operation of furnace, hr/yr
N = Number of burners to be installed, (no units)
η = Percent savings, %

$$ES = 157\ m^3/hr * 8{,}760\ hr/yr * 2 * 0\ 05 = 137{,}532\ m^3/yr \text{ or}$$
$$137{,}532 * 0\ 0318\ MMBtu/m^3 = 4{,}374\ MMBtu/yr$$

50

Figure A.1


EFFICIENCY IMPROVEMENT WITH
EACH 1% EXCESS AIR REDUCTION
EFFICIENCY IMPROVEMENT %
0 1
0.09
0.08
0 07
0 06
0 05
0.04
0 03
0 02
0 01
0
200 250 300 350 400 450 500 550 600
STACK TEMPERATURE F

53

Annual Fuel Cost Savings

Local Prices
CS_L = 137,532 m^3/yr * \$0 022 / m^3 = \$ 3,026/yr

World Prices
CS_W = 4,374 MMBtu/yr * \$4 00 / MMBtu = \$17,496/ yr

Implementation Costs

These burners are packaged units that were originally intended to reuse stack gases to reduce Nox emissions (see attached) Two five million Btu per hour burner packages with electrical components to accommodate local voltage and frequency is estimated at \$20,000 including shipping

Investment Payback (PB)

PB_{LOCAL} = \$20,000 / \$3,026 per year = 6 61 year

PB_{WORLD} = \$20,000 / \$17,496 per year = 1 14 year

A.6 ECO # 6 ENERGY MANAGEMENT PROGRAM ENHANCEMENT

This recommendation is to provide the plant necessary metering tools to identify and quantify energy conservation opportunities By metering, the plant can quantify energy savings so they can prioritize conservation technology expenditures among competing production enhancing investments

Included is typical energy management campaigns to achieve a successful basic energy conservation program These will provide example of the types of simple programs that are proven to be profitable investments of manpower

Energy awareness and conservation participation of all plant staff is crucial to a successful demand side energy management program

Savings

By using the above recommended metering tools, along with programs similar to those described in Section 4 6, a plant can effectively minimize their consumption of energy Within one year, five percent of the plant's energy will be reduced by the awareness created with the above recommended metering alone This savings will be seen in no cost / low cost management measures

$Savings_{ENERGY}$ = Total plant energy consumption x 5 %

Natural gas 13,589,000 m^3/yr * 0 05 = 679,450 m^3/yr

Electricity 16,900,000 kWh/yr * 0 05 = 845,000 kWh/yr

$Savings_{$LOCAL}$ = Total plant energy costs x 5%
= 679,450 m^3/yr * $0 022 / m^3 + 845,000 kWh/yr * $ 0 014/kWh = $26,768/yr

$Savings_{$WORLD}$ = 679,450m^3/yr * 0 0318MMBtu/m^3 * $4/MMBtu + 845,000kWh/yr * $0 064/kWh
= $140,506

$Payback_{LOCAL}$ = $33,650 / $26,768 = 1 26 year

$Payback_{WORLD}$ = $33,650 / $140,506 = 0 24 year

The following charts may be used to quantify energy savings opportunities

STEAM LOSS IN DOLLARS PER YEAR AT A FUEL PRICE OF:

$4.00 Per million BTU's

STEAM PRESSURE IN PSI	1/16 INCH HOLE	1/8 INCH HOLE	1/4 INCH HOLE	1/2 INCH HOLE
15	172	687	2,746	10,985
50	370	1,480	5,915	23,659
100	661	2,643	10,562	42,248
150	945	3,780	15,104	60,415
200	1,236	4,943	19,751	79,004
300	1,810	7,242	28,941	115,760
600	3,535	14,141	56,508	226,028

STEAM PRESSURE IN ATMOSPHERES	1/16 INCH HOLE	1/8 INCH HOLE	1/4 INCH HOLE	1/2 INCH HOLE
1.0	172	687	2,746	10,985
3 4	370	1,480	5,915	23,659
6 8	661	2,643	10,562	42,248
10 2	945	3,780	15,104	60,415
13 6	1,236	4,943	19,751	79,004
20.4	1,810	7,242	28,941	115,760
40 8	3,535	14,141	56,508	226,028

STEAM PRESSURE IN KG/SQ.CM	1/16 INCH HOLE	1/8 INCH HOLE	1/4 INCH HOLE	1/2 INCH HOLE
1 1	172	687	2,746	10,985
3 5	370	1,480	5,915	23,659
7 0	661	2,643	10,562	42,248
10 5	945	3,780	15,104	60,415
14.1	1,236	4,943	19,751	79,004
21.1	1,810	7,242	28,941	115,760
42.2	3,535	14,141	56,508	226,028

STEAM PRESSURE IN KILOPASCALS	1/16 INCH HOLE	1/8 INCH HOLE	1/4 INCH HOLE	1/2 INCH HOLE
103 4	172	687	2,746	10,985
344 7	370	1,480	5,915	23,659
689.5	661	2,643	10,562	42,248
1,034.2	945	3,780	15,104	60,415
1,379 0	1,236	4,943	19,751	79,004
2,068 4	1,810	7,242	28,941	115,760
4,136 9	3,535	14,141	56,508	226,028

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Steam Loss From Different Size Leaks At Various Pressures

STEAM LOSS IN POUNDS PER YEAR

STEAM PRESSURE IN PSI	1/16 INCH HOLE	1/8 INCH HOLE	1/4 INCH HOLE	1/2 INCH HOLE
15	30,064	120,262	480,583	1,922,292
50	64,753	259,025	1,035,103	4,140,322
100	115,630	462,545	1,848,398	7,393,432
150	165,351	661,439	2,643,209	10,572,608
200	216,228	864,959	3,456,504	13,825,718
300	316,826	1,267,373	5,064,611	20,258,004
600	618,621	2,474,616	9,888,929	39,554,861

STEAM LOSS IN KILOGRAMS PER YEAR

STEAM PRESSURE IN ATMOSPHERES	1/16 INCH HOLE	1/8 INCH HOLE	1/4 INCH HOLE	1/2 INCH HOLE
1 0	13,665	54,664	218,447	873,769
3 4	29,433	117,739	470,501	1,881,965
6 8	52,559	210,248	840,181	3,360,651
10 2	75,159	300,654	1,201,459	4,805,731
13 6	98,286	393,163	1,571,138	6,284,417
20 4	144,012	576,079	2,302,096	9,208,183
40 8	281,191	1,124,825	4,494,968	17,979,482

STEAM LOSS IN KILOGRAMS PER YEAR

STEAM PRESSURE IN KG/SQ CM	1/16 INCH HOLE	1/8 INCH HOLE	1/4 INCH HOLE	1/2 INCH HOLE
1 1	13,665	54,664	218,447	873,769
3 5	29,433	117,739	470,501	1,881,965
7 0	52,559	210,248	840,181	3,360,651
10 5	75,159	300,654	1,201,459	4,805,731
14 1	98,286	393,163	1,571,138	6,284,417
21.1	144,012	576,079	2,302,096	9,208,183
42 2	281,191	1,124,825	4,494,968	17,979,482

STEAM LOSS IN KILOGRAMS PER YEAR

STEAM PRESSURE IN KILOPASCALS	1/16 INCH HOLE	1/8 INCH HOLE	1/4 INCH HOLE	1/2 INCH HOLE
103 4	13,665	54,664	218,447	873,769
344 7	29,433	117,739	470,501	1,881,965
689 5	52,559	210,248	840,181	3,360,651
1,034 2	75,159	300,654	1,201,459	4,805,731
1,379 0	98,286	393,163	1,571,138	6,284,417
2,068 4	144,012	576,079	2,302,096	9,208,183
4,136 9	281,191	1,124,825	4,494,968	17,979,482

LIGHTING ENERGY COST - TOTAL FIXTURE CONSUMPTION WITH BALLAST

(based on, medium or mogal base, clear, general service, Philips Brand lamps)

OPERATION COST BASED ON KWH PRICE OF **$0.064** PER KWH

INCANDESCENT	TOTAL WATTS	INITIAL LUMENS OUTPUT	INITIAL LUMENS PER WATT	SERVICE LIFE	COST	1000 HOURS PER YEAR	2000 HOURS PER YEAR	3000 HOURS PER YEAR	4000 HOURS PER YEAR	5000 HOURS PER YEAR	6000 HOURS PER YEAR	7000 HOURS PER YEAR	8000 HOURS PER YEAR	8760 HOURS PER YEAR
15 watt	15	126	8 4	2500	$2 11	$1	$2	$3	$4	$5	$6	$7	$8	$8
25 watt	25	260	10 4	1000	$1 31	$2	$3	$5	$6	$8	$10	$11	$13	$14
40 watt	40	480	12 0	1500	$1 31	$3	$5	$8	$10	$13	$15	$18	$20	$22
60 watt	60	890	14 8	1000	$1 14	$4	$8	$12	$15	$19	$23	$27	$31	$34
75 watt	75	1220	16 3	750	$1.31	$5	$10	$14	$19	$24	$29	$34	$38	$42
100 watt	100	1750	17 5	750	$1 31	$6	$13	$19	$26	$32	$38	$45	$51	$56
150 watt	150	2850	19 0	750	$1 87	$10	$19	$29	$38	$48	$58	$67	$77	$84
200 watt	200	3900	19 5	750	$2 25	$13	$26	$38	$51	$64	$77	$90	$102	$112
300 watt	300	6300	21 0	750	$3 20	$19	$38	$58	$77	$96	$115	$134	$154	$168
500 watt	500	10750	21 5	1000	$7 61	$32	$64	$96	$128	$160	$192	$224	$256	$280
750 watt	750	16700	22 3	1000	$23 85	$48	$96	$144	$192	$240	$288	$336	$384	$420
1000 watt	1000	23100	23 1	1000	$18 14	$64	$128	$192	$256	$320	$384	$448	$512	$561
1500 watt	1500	33300	22 2	1000	$29 60	$96	$192	$288	$384	$480	$576	$672	$768	$841
FLUORESCENT														
2 x 40 watt lamps standard C&C ballast cool white lamps	95	6100	64 2	20000		$6	$12	$18	$24	$30	$36	$43	$49	$53
2 x 32 watt lamps electronic ballast F032 tri phos lamps	58	6100	105 2	20000	$45 00 2 lamps & electronic ballast	$4	$7	$11	$15	$19	$22	$26	$30	$33

LIGHTING ENERGY USE - TOTAL FIXTURE KILOWATT-HOURS WITH BALLAST

(based on, medium or mogal base, clear, general service, Phillips Brand lamps)

INCANDESCENT	TOTAL WATTS	INITIAL LUMENS OUTPUT	INITIAL LUMENS PER WATT	SERVICE LIFE	COST	1000 HOURS PER YEAR	2000 HOURS PER YEAR	3000 HOURS PER YEAR	4000 HOURS PER YEAR	5000 HOURS PER YEAR	6000 HOURS PER YEAR	7000 HOURS PER YEAR	8000 HOURS PER YEAR	8760 HOURS PER YEAR
15 watt	15	126	8.4	2500	$2 11	15	30	45	60	75	90	105	120	131
25 watt	25	260	10 4	1000	$1 31	25	50	75	100	125	150	175	200	219
40 watt	40	480	12 0	1500	$1 31	40	80	120	160	200	240	280	320	350
60 watt	60	890	14 8	1000	$1 14	60	120	180	240	300	360	420	480	526
75 watt	75	1220	16 3	750	$1 31	75	150	225	300	375	450	525	600	657
100 watt	100	1750	17 5	750	$1 31	100	200	300	400	500	600	700	800	876
150 watt	150	2850	19 0	750	$1 87	150	300	450	600	750	900	1,050	1,200	1,314
200 watt	200	3900	19 5	750	$2 25	200	400	600	800	1,000	1,200	1,400	1,600	1,752
300 watt	300	6300	21 0	750	$3 20	300	600	900	1,200	1,500	1,800	2,100	2,400	2,628
500 watt	500	10750	21 5	1000	$7 61	500	1,000	1,500	2,000	2,500	3,000	3,500	4,000	4,380
750 watt	750	16700	22 3	1000	$23 85	750	1,500	2,250	3,000	3,750	4,500	5,250	6,000	6,570
1000 watt	1000	23100	23 1	1000	$18 14	1,000	2,000	3,000	4,000	5,000	6,000	7,000	8,000	8,760
1500 watt	1500	33300	22 2	1000	$29 60	1,500	3,000	4,500	6,000	7,500	9,000	10,500	12,000	13,140
FLUORESCENT														
2 x 40 watt lamps standard C&C ballast cool white lamps	95	6100	64 2	20000		95	190	285	380	475	570	665	760	832
2 x 32 watt lamps electronic ballast F032 tri phos lamps	58	6100	105 2	20000	$45 00 2 lamps & electronic ballast	58	116	174	232	290	348	406	464	508

APPENDIX B
Photographs of Facility and Equipment

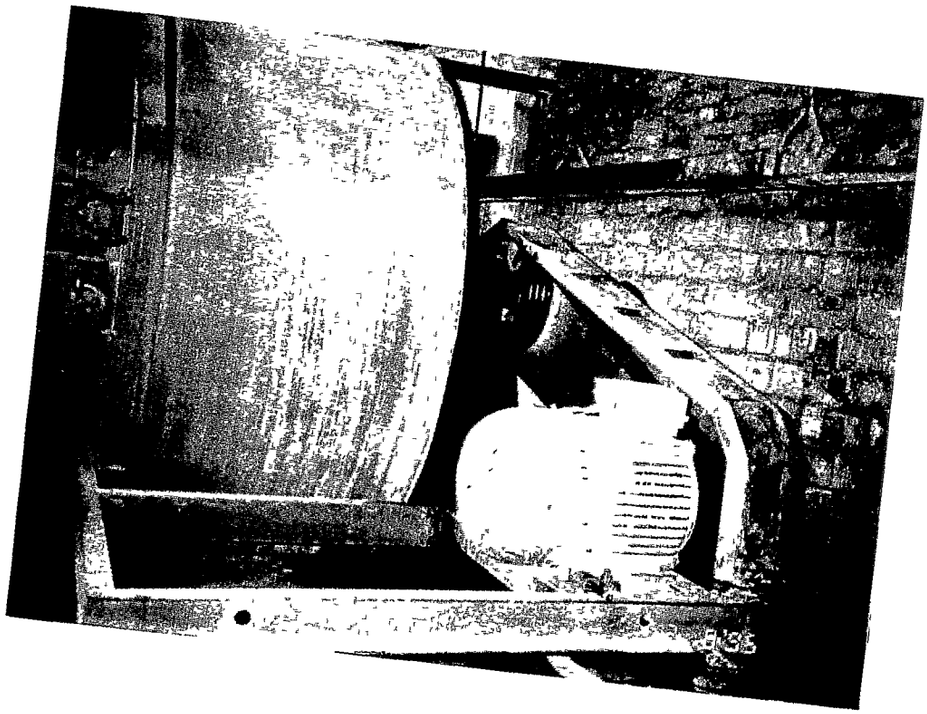
Photograph #3 - Glass making furnace. Combustion monitoring.

Photograph #4 - Combustion air inlet

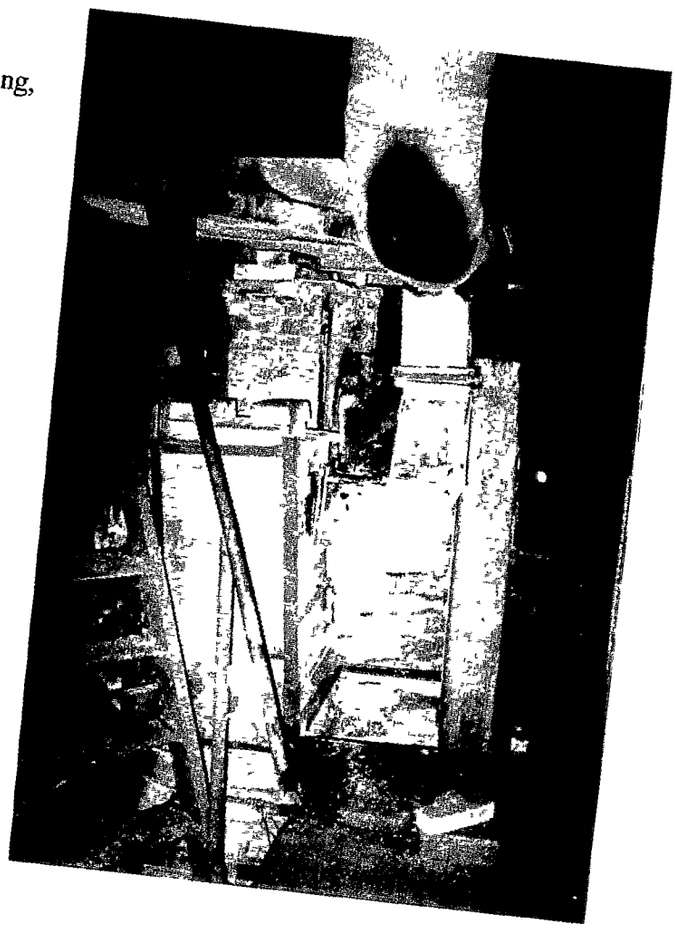
Photograph #1 - Audit team, local engineer, and interpreter

Photograph #2 - Plant energy management staff

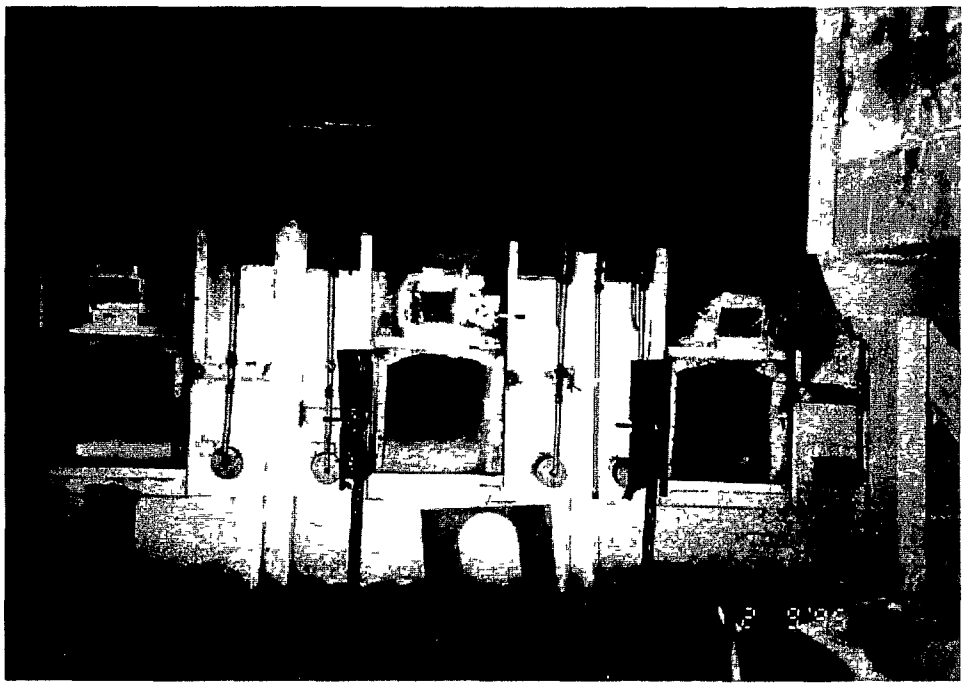
Photograph #5 - Ventilation fan and 30 kW motor



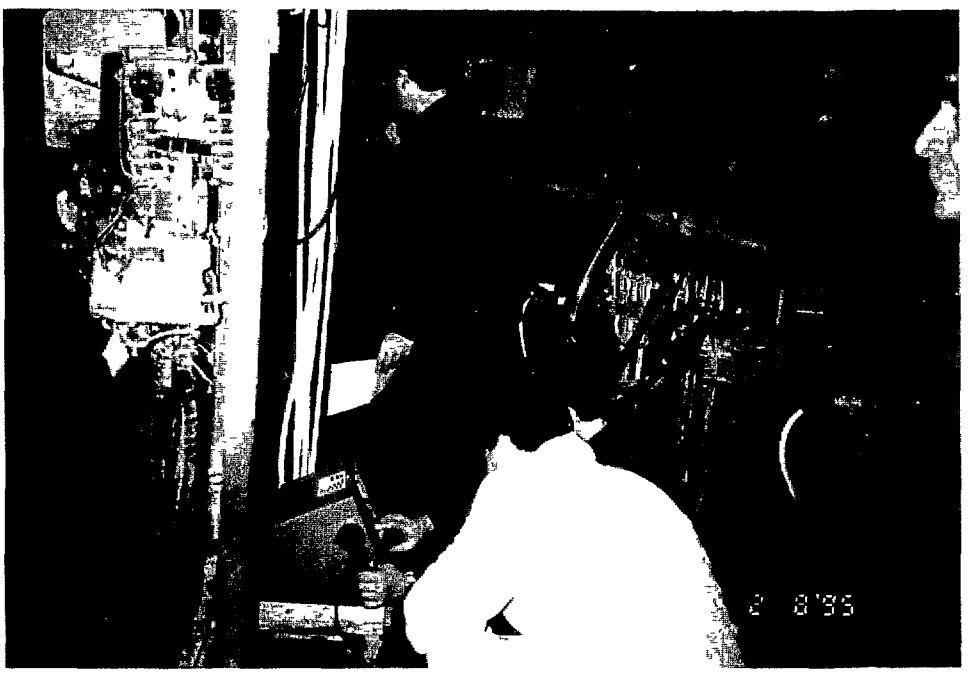
Photograph #6
Molten glass holding,
Furnace burner,
and Exhaust stack



Photograph #7 - Annealing oven, heating and loading



Photograph #8 - Monitoring electrically heated glass furnace



APPENDIX C
Kiev Glass Plant Product Catalog Sample
Glass Plant Advertisement for Privatization

Київський завод художнього скла

Kiev artistic glass ware plant

Видувні вироби

Рюмки, бокали, фужери

Blowing-out wares

Glasses, goblets, tall wine glasses

N 4900
місткість см3 190, 185, 75, 50, 35

Бокали для весілля
N 4890
H-240
місткість 300 см3
N 5269
H-223
місткість 170 см3
N 5461-1
H-231
місткість 400 см3
N 4774-1
H-298
місткість 275 см3

N 6701
місткість см3 240, 220, 100, 75, 50

66

Київський завод художнього скла

Kiev artistic glass ware plant

Видувні вироби

Вази для квітів

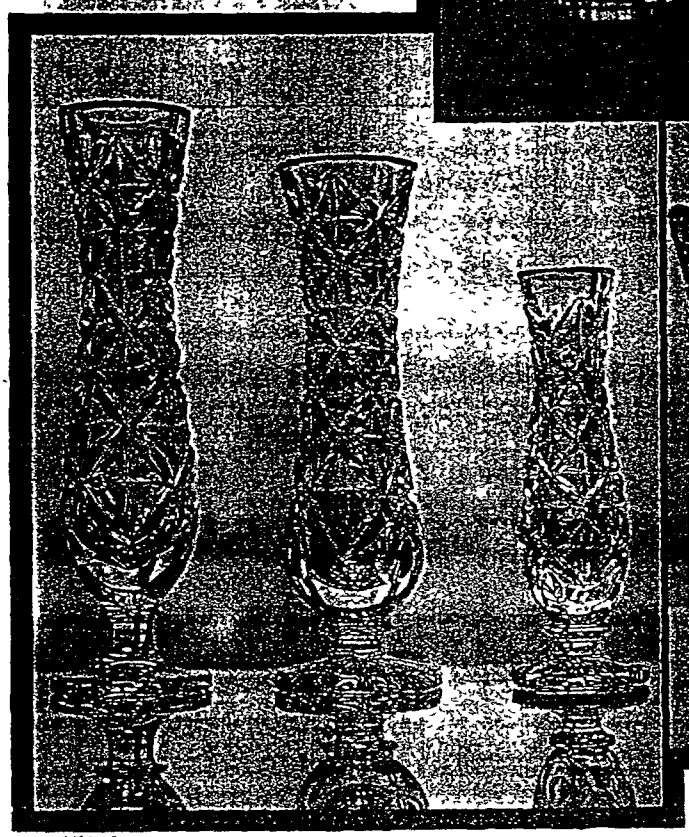
Blowing-out wares

Flower vases

N 6631
H–290 D–175
N 6633
H–208 D–137
N 6632
H–238 D–163

N 4102–4
H–300 D–72
N 4102–5
H–270 D–72
N 4102–6
H–211 D–53

N 4677
H–248 D–145
N 4678
H–202 D–115
N 4679
H–150 D–102



Київський завод художнього скла

Kiev artistic glass ware plant

Вази для сервування столу

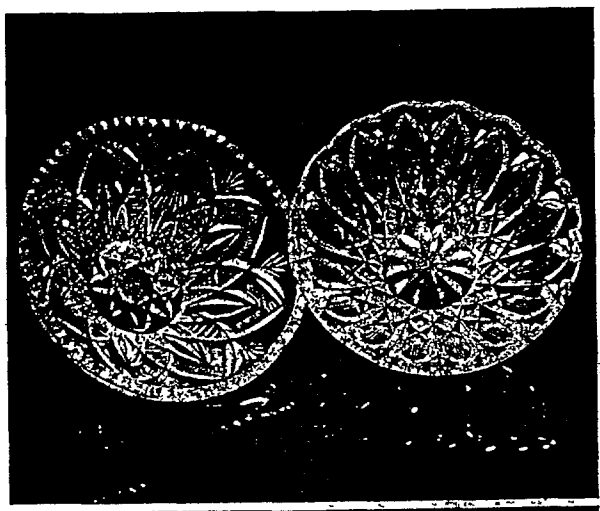
Салатниці

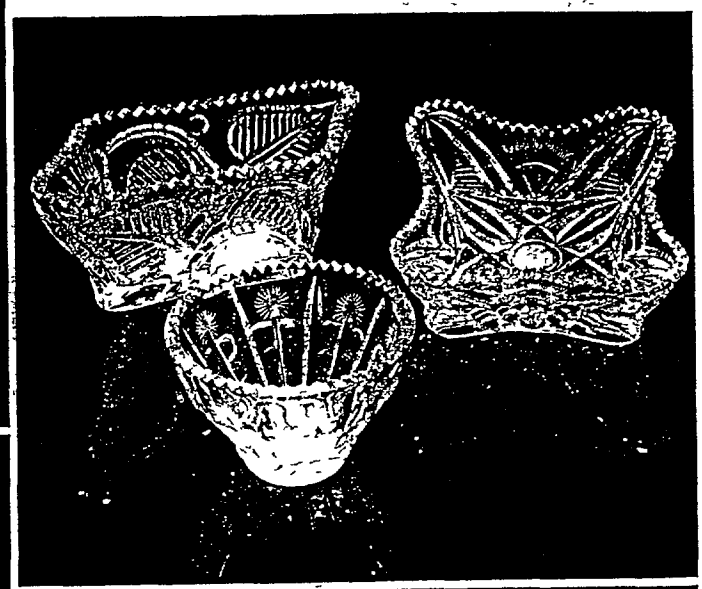
Table appointments vases

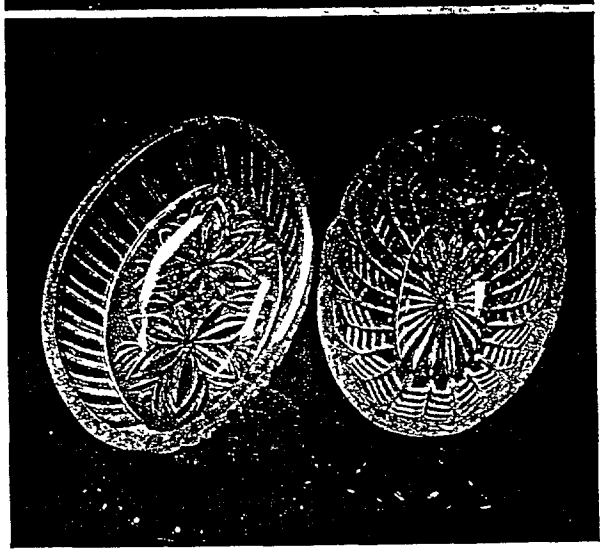
Salad - bowls

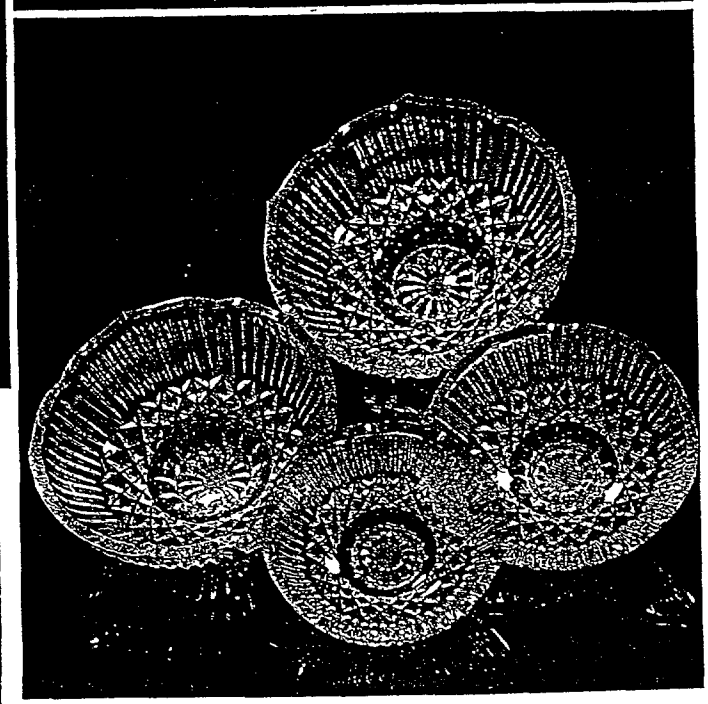
N 6379
H–83 D–208

N 5098
H–88 D–211









N 5887
H–53 D–265x185

N 6020
H–64 D–265x165

N 6011
H–88 D–236

N 5087
H–82 D–127

N 5350
H–67 D–216

N 6414
H–92 D–210

N 6414–1
H–83 D–190

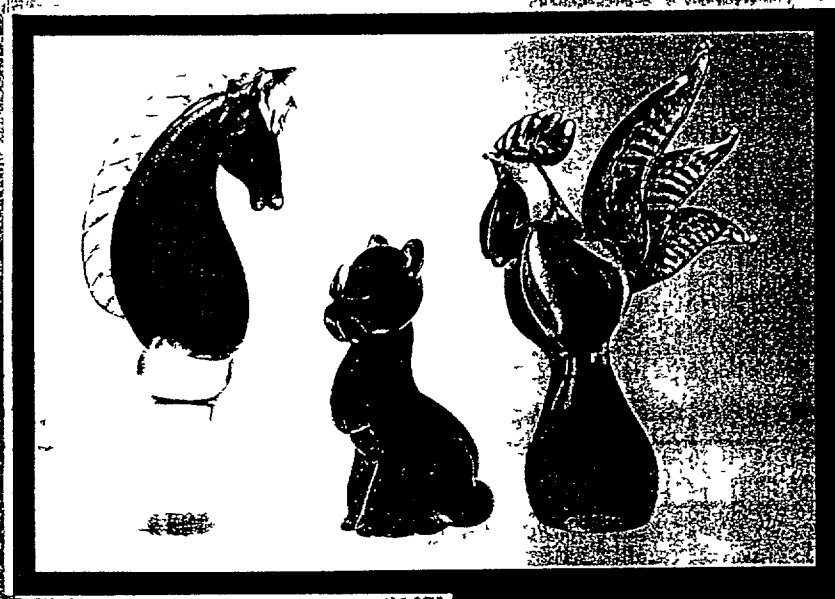
N 6414–2
H–68 D–160

N 6414–3
H–58 D–135

Київський завод художнього скла

Kiev artistic glass ware plant

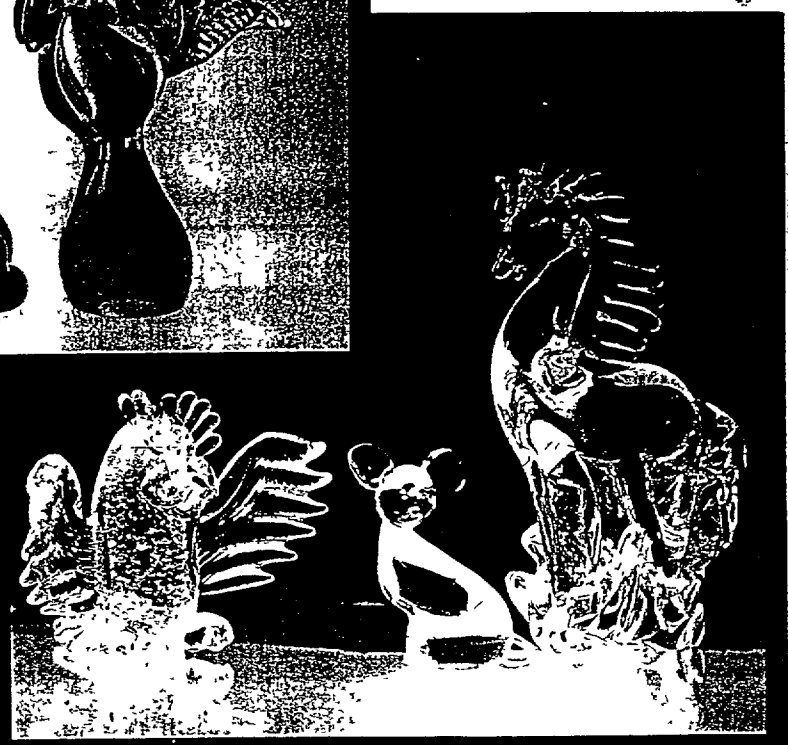
Скульптура
Sculpture

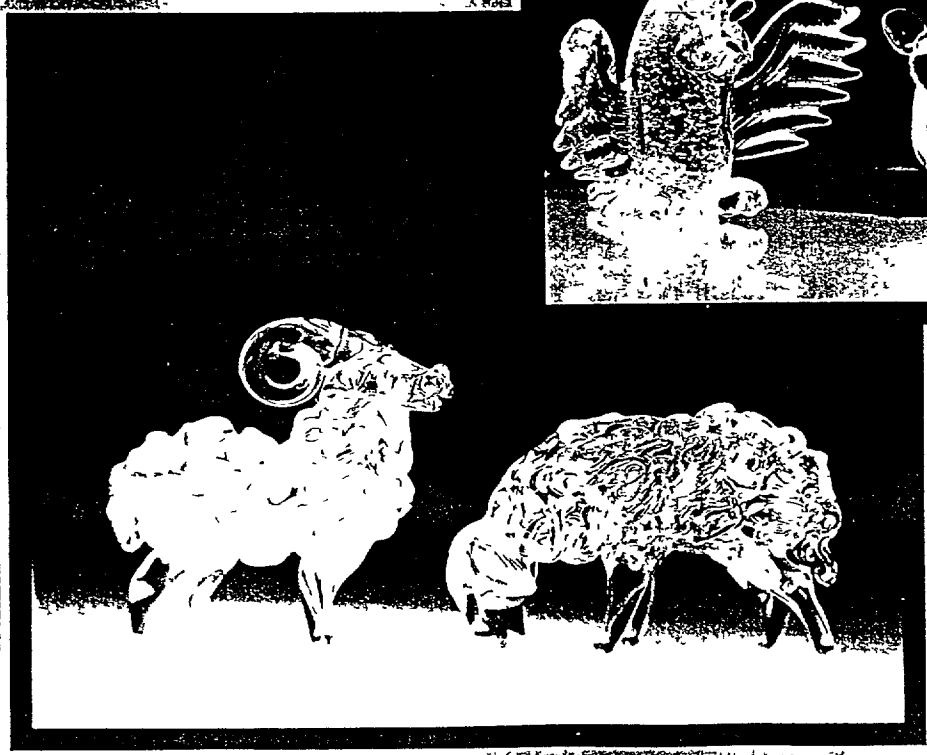


Шахматний кінь
N 6449
H–215 L–110

Кіт
N 5960
H–130 L–70

Півень
N 6655
H–218





Сова
N 6017
H–100 L–130

Миша
N 6016
H–95

Кінь
N 6406
H–225 L–150

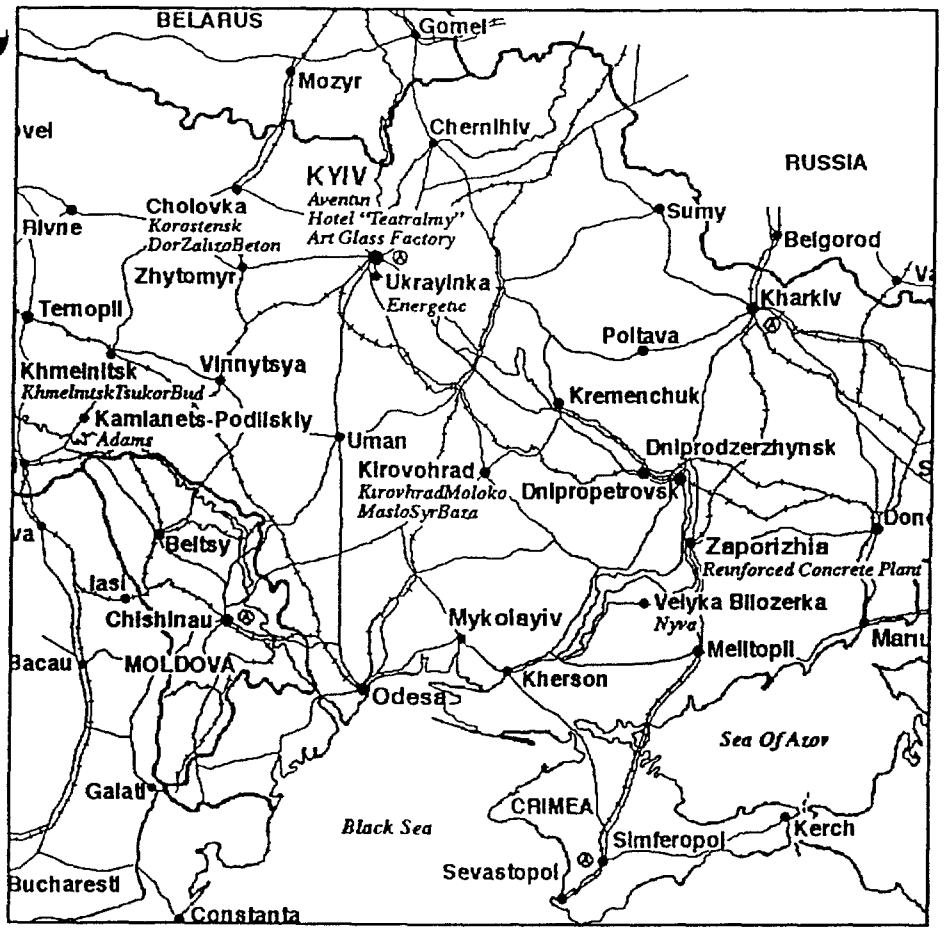
Баран
N 6588
H–110 L–140

Вівця
N 6587
H–87 L–135

69

PRIVATIZATION

BUSINESSES FOR SALE



IntelNews Graphics

CONSTRUCTION

Korostensk DorZalizoBeton
Reinforced concrete kits consumer goods Sales KBV 1 50 bn (for the first four months of 1994) Profits KBV1 76 bn (for the first four months of 1994) 174 employees Assets KBV1 8 bn, shares KBV 854 mn available for privatization certificates Submit bid before Feb 26 Located in Zhytomir oblast Korostensk district Cholovka village

Zaporizhia Reinforced Construction Plant
Reinforced construction kits concrete products Sales KBV4 1 bn (in 1993 prices) Profits KBV898 mn (1993) 186 employees Assets KBV1 57 bn shares KBV841 mn available for privatization certificates Submit bid before March 1 Located in Zaporizhia

KhmelnitskTsukorBud
Construction-erection works Sales KBV4 65 (1993 in 1992 prices) Profits KBV2 1 bn (1993) 740 employees Assets KBV2 42 bn shares KBV936 mn available for privatization certificates Submit bid before March 1 Located in Khmelnitsk Prybuzska str, 54

FOOD & DRINK

Nyva
Milk meat grain sunflower seeds Sales KBV3 bn (1993) Profits 6 66 bn (1994) 308 employees Assets KBV11 44 bn shares KBV5 11 bn available for privatization certificates Submit bid before March 1 Located in Zaporizhia obl, Velyka Bilozerka village

KirovohradMoloko
Butter cheese dairy products Sales KBV96 19 bn (1993) Profits KBV4 07 bn (1993) 1,226 employees Assets KBV31 24 bn shares KBV6 28 bn available for privatization certificates Submit bid before March 1 Located in Kirovohrad Dzerzhinskoho str, 84/37

Kirovohrad MasloSyrBaza
Dairy products Sales KBV3 34 bn (1993) Profits KBV1 3 bn (1993) 142 employees Assets KBV5 5 bn shares KBV1 62 bn available for privatization certificates Submit bid before March 1 Located in Kirovohrad, Tereshkovoi str 217

Adams
Vegetable and meat cans Sales KBV14 75 bn (for the first nine months of 1994) Profits KBV6 7 bn (for the first nine months of 1994) 1 344 employees Assets KBV19 48 bn shares KBV9 51 bn available for privatization certificates Submit bid before March 1 Located in Kamianets-Podilskiy city (Khmelnitsk obl) Matrosova str 1

WHOLESALE AND RETAIL

Energetic
Consumer goods retail Sales KBV19 52 bn (1993) Profits KBV 107 mn (for the first month of 1994) 605 employees Assets KBV3 04 bn shares KBV 2 07 bn available for privatization certificates Submit bid before March 1 Located in Ukrayinka (Kyiv obl) Sosnova str 3

Aventin
Consumer goods wholesale and retail foreign trade activity Sales KBV33 31 bn (1993) Profits KBV1 26 bn (1994) 390 employees Assets KBV5 58 bn shares KBV3 07 bn available for privatization certificates Submit bid before March 1 Located in Kyiv Kalachevskoho str 13

GENERAL

Hotel "Teatralnyi"
Hotel services Sales KBV3 04 bn (for the first four months of 1994) Profits KBV731 mn (for the first four months of 1994) 85 employees Assets KBV1 47 bn shares KBV441 mn available for privatization certificates Submit bid before March 1 Located in Kyiv Holosiivska str, 7

Kyiv Art Glass Factory
Crystal products Sales KBV240 bn (1994) Profits KBV14 83 bn (1994) 1 880 employees Assets KBV11 57 bn shares KBV5 64 bn available for privatization certificates Submit bid before March 1 Located in Kyiv, Chervonozoriany avenue 119

Source State Property Fund
Prepared by IntelNews with material from bulletin Vidomosti Privatyzatsii

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Please Contact Adrian Pidlusky, Tel/Fax (044) 228-7440

APPENDIX D
World Energy Prices
Plant Energy Consumption History
Glass Furnace Demand Profile

Table D.1 World Energy Prices; OECD Europe

Industrial Sector	Fuel	US$/toe	US$/mm Btu	US$ per
	Light Fuel Oil	290	7	383 tonne
	Heavy Fuel Oil	151	4	158 tonne
	Electricity	742	19	0 064 kWh
	Natural Gas	151	4	141 km^3
	Steam Coal	128	3	90 tonne
	Coking Coal	92	2	58 tonne
	Thermal	298	8	30 Gcal

Plant Energy ConsumptionHistory

TABLE D.2 INDUSTRIAL OUTPUT
(Brought to the prices at 01 01 93)
Rate of exchange at 01 01 93 was $ 1 US = 650 8 krb

Year	Industrial output per same prices		Dynamic of Changes,
	Millions Ukrainian krb	Millions $ US	Present year to Previous One(%)
1991	143,708	220 8	
1992	162,587	249 8	113 1
1993	171,968	264 2	105 8
1994	143,074	219 8	83 2

TABLE D.3 CONSUMPTION OF DIFFERENT TYPES OF ENERGY

Type of Energy	Unit	Year 1991	Year 1992	Year 1993	Year 1994
Natural Gas	000 cub m	18236	17264	14748	13589
Electricity	000 kW h	12393	11259	11227	12518 [4]
Water	000 cub m	1398 1	742 0	766 2	707 5

[4] There are discrepancies between data on electricity consumption obtained from facility staff and presented in Tables d 2-d 6 Table D 6 presents official statistics, so it is accepted in this report

TABLE D.4 EXPENSES FOR PURCHASE OF DIFFERENT TYPE OF ENERGY

Type of Energy	Year 1991 ($ 1 US = 41 Rub)		Year 1992 ($ 1 US = krb)		Year 1993 ($ 1 US = 6300 krb)		Year 1994 ($ 1 US = 65000 krb)	
	000 Rub	000 $ US	000 Krb	000 $ US	Million krb	000 $ US	Million Krb	000 $ US
Natural Gas	1212 3	29 57	23514		2001 3	317 667	19415 8	298 705
Electricity	645 7	15 75	22104 4		1232 8	195 682	11238 3	172 897
Water	1391 8	33 95	47805 5		2283 7	362 492	25950	399 231
Total	3250 8	79 29	93423 9		5517 8	875 841	56604 1	870 832

TABLE D.5 SHARE OF EXPENSES ON ENERGY IN THE COST OF PRODUCTION (%)

Type of Energy	Year 1991	Year 1992	Year 1993	Year 1994
Natural Gas	4 0	4 9	10 5	9 6
Electricity	2 0	4 6	6 5	5.5
Water	4.8	10 0	12 1	12 8
Total	10 8	19 6	29 1	27 9

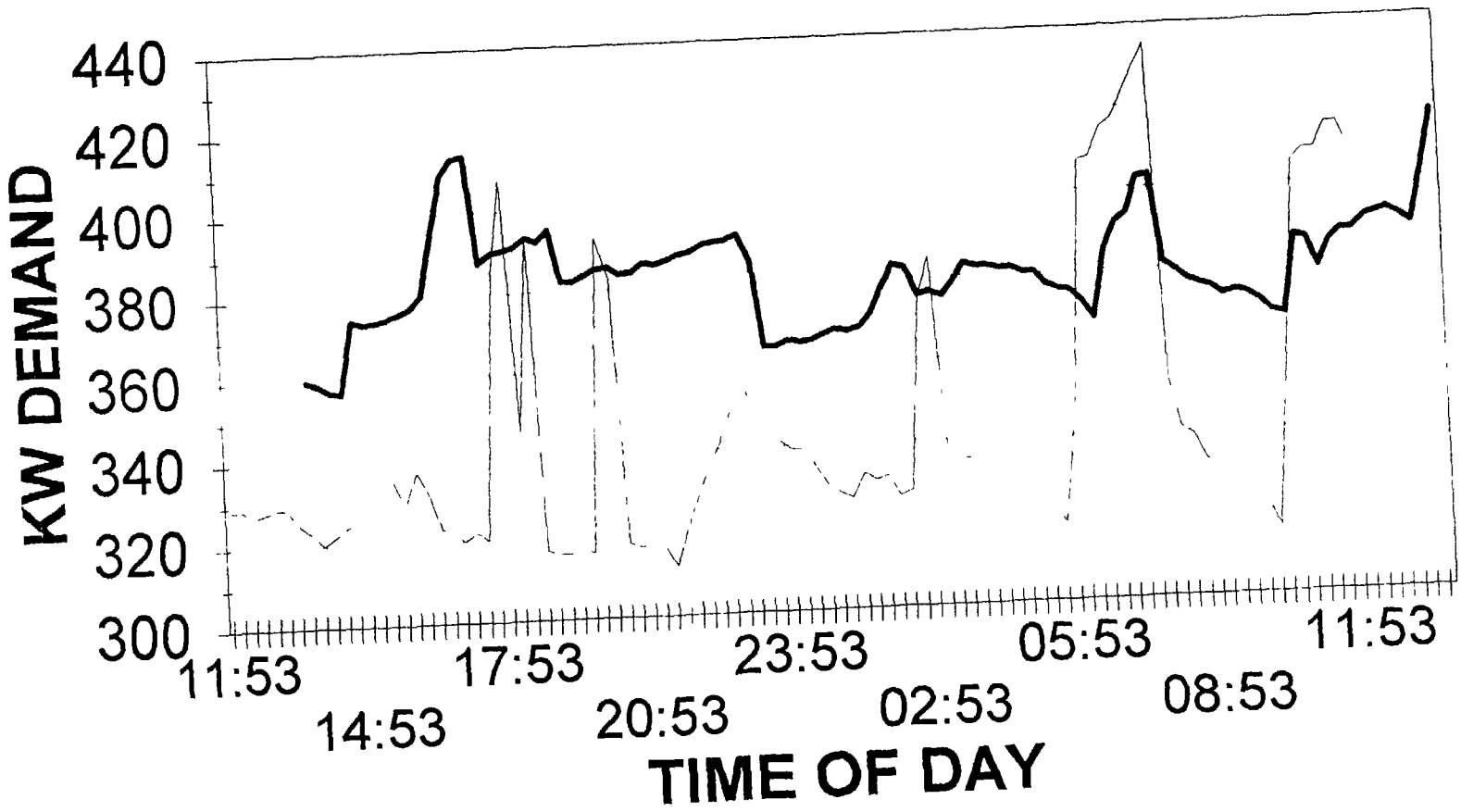
TABLE D.6 ELECTRICITY CONSUMPTION AT THE YEAR 1994 (000 kW.h)

Total by facility	16,900
Out of it	
For process needs	8,100
By motors	8,110
Lighting	600
Losses in lines and transformers	90

-15

ELECTRIC GLASS FURNACE # 5 & # 6

(Feb 8-9, #6) (Feb 9-10, #5)



Unit #1 Power Analyzer #4

Fri, Feb 10, 1995

H Highest L Lowest # >= 1000K

Time	KW	PF	Time	KW	PF	Time	KW	PF
00:08 L	365.20	0.89	08:08	379.60	0.89			
00:23	365.60	0.89	08:23	377.10	0.89			
00:38	367.00	0.89	08:38	375.90	0.89			
00:53	368.30	0.89	08:53	375.20	0.89			
01:08	367.40	0.89	09:08	373.00	0.89			
01:23	368.40	0.89	09:23	374.10	0.89			
01:38	371.50	0.89	09:38	373.10	0.89			
01:53	378.00	0.89	09:53	371.20	0.89			
02:08	383.50	0.89	10:08	368.60	0.89			
02:23	382.60	0.89	10:23	367.90	0.89			
02:38	375.50	0.89	10:38	386.80	0.90			
02:53	376.50	0.89	10:53	386.20	0.90			
03:08	375.30	0.89	11:08	379.00	0.90			
03:23	378.70	0.89	11:23	385.30	0.90			
03:38	383.00	0.89	11:38	387.80	0.91			
03:53	382.20	0.89	11:53	387.90	0.91			
04:08	382.30	0.89	12:08	390.90	0.91			
04:23	381.50	0.89	12:23	391.80	0.91			
04:38	381.80	0.89	12:38	392.60	0.91			
04:53	380.30	0.89	12:53	391.00	0.91			
05:08	380.30	0.90	13:08	388.90	0.91			
05:23	377.00	0.90	13:23	401.90	0.91			
05:38	375.90	0.89	13:38 H	416.10	0.92			
05:53	375.40	0.89						
06:08	372.60	0.89						
06:23	368.40	0.90						
06:38	385.40	0.91						
06:53	391.90	0.91						
07:08	393.90	0.91						
07:23	402.40	0.91						
07:38	403.00	0.91						
07:53	381.40	0.89						

Usage 5195.5KWH 0.90PF Average

Demand Report Fri, Feb 10, 1995 02:58:38 PM

Unit #1 Power Analyzer #4

Thu, Feb 9, 1995

H Highest L Lowest # >= 1000K

Time	KW	PF	Time	KW	PF	Time	KW	PF
12:08	0.00	0.95	20:08	385.50	0.89			
12:23	0.00	0.99	20:23	383.60	0.89			
12:38 L	-54.07	0.39	20:38	384.10	0.89			
12:53	249.50	0.96	20:53	386.20	0.90			
13:08	4.91	0.99	21:08	385.70	0.90			
13:23 H	982.70	0.99	21:23	386.70	0.90			
13:38	359.90	0.90	21:38	387.70	0.90			
13:53	358.50	0.90	21:53	388.50	0.90			
14:08	357.00	0.90	22:08	389.90	0.90			
14:23	356.60	0.90	22:23	390.70	0.90			
14:38	374.20	0.91	22:38	391.10	0.90			
14:53	373.50	0.91	22:53	392.40	0.90			
15:08	373.80	0.91	23:08	385.50	0.90			
15:23	374.50	0.91	23:23	364.20	0.89			
15:38	375.50	0.91	23:38	364.50	0.89			
15:53	377.10	0.91	23:53	365.80	0.89			
16:08	379.90	0.91						
16:23	396.00	0.91						
16:38	409.20	0.92						
16:53	413.20	0.92						
17:08	413.70	0.92						
17:23	387.40	0.90						
17:38	389.80	0.90						
17:53	390.40	0.90						
18:08	391.30	0.90						
18:23	393.20	0.90						
18:38	392.30	0.90						
18:53	395.10	0.90						
19:08	382.30	0.89						
19:23	382.40	0.89						
19:38	383.80	0.89						
19:53	385.00	0.89						

Usage 4360.7KWH 0.90PF Average

APPENDIX E
List of Contacts Made During Site Audit

LIST OF CONTACTS

KIEV TELEPHONE COUNTRY AND CITY CODE (7 044)

PLANT ADDRESS
Ukraine, 252039 Kiev,
Krasnozvezdny Prospect 119
Kiev Artistic Glass Factory
PLANT FAX
(7 044) 264-7046

Victor T Tchernetsky
Chief of Engineering
Work Phone 267-7622
[redacted]

Yuri A Povoroznyuk
Chief Mechanical Engineer
Work Phone 264-5053

Larissa Ya Matveyhchuk
Chief Process Engineer
Phone 264-6111 or 267-7370

Vasieley M Kryzhanovsky
Deputy Chief of Engineering in
Charge of Economic
Phone contact via Chief Engineer

Feliks F Chekhonin
Chief Energy Manager
Phone 264-0905

Leonid T Prokopov
Deputy Chief of Electrical Shop

Aleksy F Khripun
Chief of Thermal and Power
Shop
Phone 264-3575

Valentina V Artemenko
Director of Department of
Planning and Wages

Local Services

USAID Regional Mission - Ukraine,
Belarus, Moldova
Andriy Parinov
Energy and Natural Resources Program
Advisor
Phone (7 044) 220-9013 or 5097 or
8395 or 5589
Fax (7 044) 220-7079
Address USAID Mission in
Ukraine
19th Floor
8/10 Esplanadna Street
252023 Kiev, Ukraine

Local Engineer from Kievenergo
Peter Garkoun, Director of Department of
Means of Supervisory and Process Control
Telephone 442-0338 (off), 264-7709
(home)

APPENDIX F
USAID Letter of Audit Intent - Ukrainian Translation

USAID

U.S. AGENCY FOR
INTERNATIONAL
DEVELOPMENT

24 жовтня 1994 року

Кого це може стосуватися

Агентство США з Міжнародного Розвитку (USAID), що є офіційною частиною Посольства США в Києві, Україні засвідчує Вам свою повагу і має за честь надати наступну інформацію.

Агентство США з Міжнародного Розвитку є урядовим органом, що здійснює технічну та гуманітарну допомогу Україні в таких галузях як охорона здоров'я, приватизація, охорона навколишнього середовища, енергетика та природні ресурси. Стосовно програм з енергетики, одним з важливих проектів є підвищення ефективності використання енергії в промислових підприємствах. Здійснюють цей проект три американські фірми Burns and Roe Enterprises, Foster Wheeler, Resource Management Associates

Завданням зазначених вище фірм є проведення аудиторської роботи в декількох підприємствах, що інтенсивно споживають електроенергію, визначити заходи щодо зменшення рівня споживання енергії, та визначити типи обладнання для проведення демонстраційного проекту Агентство США з Міжнародного Розвитку має намір надати до 100 тис доларів США на обладнання для демонстраційного проекту кожному з визначених підприємств. Сподіваємося, що керівництво підприємств погодиться провести монтаж цього обладнання та періодично проводити виміри щодо споживання енергії в умовах роботи нового енергозберігаючого обладнання.

В Агентстві США з Міжнародного Розвитку ми сподіваємося, що за допомогою високоефективного енергозберігаючого обладнання можна значно ефективніше використовувати енергію і розповсюдити цей досвід в Україні.

Сподіваємося на Ваше розуміння важливості цієї роботи в тих складних умовах з енергопостачанням в Україні. Ваша підтримка надасть можливість безкоштовно для підприємств встановити обладнання, за допомогою якого з'явиться можливість зберігати енергію.

З повагою,

Андрій Парінов
Радник керівника програм з енергетики

F 1

320 TWENTY FIRST STREET NW WASHINGTON DC 20523

APPENDIX G
Audit Equipment List

RESOURCE MANAGEMENT ASSOCIATES
of Madison, Inc

202 State Street
Suite 303
Madison, WI 53703 U.S.A.

Telephone 608/283 2880
Facsimile 608/283 2881

EQUIPMENT TURNED OVER TO THE KIEV OFFICE OF THE UNITED STATES AGENCY FOR INTERNATIONAL DEVELOPMENT (USAID) c/o IDEA\PADCO

ITEM	EQUIPMENT DESCRIPTION	QUANTITY	RECEIVED
1	Platinum RTD thermometer w/ probes	1	DMP
2	Wahl Heat Spy infrared thermometer	1	DMP
3	Rechargeable battery pack for Heat Spy	1	DMP
4	TIF 2000A clamp-on digital wattmeter	1	DMP
5	Fluke 85 digital multimeter	1	DMP
6	Fluke 80i-410 current probe for multimeter	1	DMP
7	TIF 2300 power factor meter	1	DMP
8	Sperry SLM-110 digital light meter	1	DMP
9	Kurz 444 hot wire anemometer	1	DMP
10	24" probe for Kurz anemometer	1	DMP
11	Battery recharger	1	DMP
12	Voltage converter	2	DMP
13	Foreign plug adaptor	2	DMP
14	Rechargeable 9 volt batteries	12	DMP
15	Dranetz / PowerStar manuals	1	DMP
16	Dranetz 808A power analyzer including - 3 current probes, cables, paper	1	DMP
17	Canon INNOVA laptop computer	1	DMP
18	HP DeskJet printer	1	DMP
19	Nova Strobe DB stroboscopic tachometer	1	DMP
20	Bacharach 300NSX combustion analyzer	1	DMP
21	Bacharach 48" probe for combustion analyzer	1	DMP

The equipment listed above has been turned over to the Kiev office of the United States Agency for International Development (USAID) By signing this form the receiver accepts full responsibility for the care and custody of all items and must be able to provide accountability reports if requested This equipment was originaly procured by Burns & Roe Company and is being turned over on their behalf

Turned over by:		Received by:	
Signature:	Doug Presny	Signature	Darian Diachok
Name:	DOUG PRESNY	Name	DARIAN DIACHOK
Title	ENERGY ENGINEER	Title:	CHIEF-OF-PARTY, IDEA\PADCO - KIEV
Date	FEB 22, 1995	Date	FEB. 22, 1995

APPENDIX H
Standard Abbreviations and Conversions Used In Report

Glossary

AC	Alternating Current
amps	amperes
atm	atmosphere(s) - 14 696 pounds per square inch
bar	100,000 pascals - 14 504 pounds per squared inch
BTU or Btu	British thermal unit
cfm	cubic feet per minute
cm	centimeter = 0 3927 inches
cm^2	square centimeter - 0 155 square inches
CO	carbon monoxide
CO_2	carbon dioxide
°C	degree(s) CelsiusT = 5/9 [T° F - 32]
° F	degree(s) FahrenheitT
° R	degree(s) RankineT = T° F + 460
DC	Direct Current
DSM	Demand-Side Management
E	East
EAF	Electric Arc Furnace
ECO	Energy Conservation Opportunity
eff	efficiency
EEM	Energy Efficiency Measure
ex air	excess air
ft^2	square feet
ft^3	cubic feet
Gcal	Gigacalorie(s) = 1 billion calories = 3 968 million BTU
GJ	Gigajoule(s) = 1 billion joules
gph	US gallons per hour
gpm	US gallons per minute
GWh	GigaWatt hour(s) = (10^6 kWh) = 1 billion watt hours
H_2	hydrogen
H_2O	water
H_2SO_4	sulfuric acid
hectare	10,000 square meters = 2 471 acres
hectoliter	100 liters = 26 42 US gallons
Hg	mercury
hp	horsepower
hps	high-pressure sodium lighting
hr	hour
Hz	hertz = cycles per second
J	joule(s)
kcal	kilocalories = 1 thousand calories = 3 968 BTU
kg	kilogram

Kgcc	7,000 kcal = 27,776 BTU
kJ	kilojoules = 1 thousand joules = 0 947813 BTU
km	kilometer = 0 621 miles
kN	kilonewton = 1 thousand newtons
kp	kopeck = 01 ruble
kPa	kilopascal(s) = 1 thousand pascals = - 14504 pounds per square inch
kV	kilovolts = 1 thousand volts
kVA	kilovolt-amperes
kVAr	kilovars = 1 thousand volt=amperes (reactive)
kW	kiloWatt(s)
kWh	kiloWatt hour(s)
lb(s)	pound(s)
liter	0 2642 US gallons = 0 03531 cubic feet
m	meter(s)
m^2	square meter(s)
m^3	cubic meter
mA	milliampere = 0 001 amperes
MBTU or MMBTU	mega BTU = 1 million BTU
MCal	megacalorie = 1 million calories
metric ton	1 thousand kilograms = 1 1023 US tons
mg	milligram(s)
min	minute
MCF	one thousand cubic feet
MJ	megajoules
MM or mln	million
MPa	1 million pascals = 145 04 pounds per square inch
mv	mercury vapor lighting
MW	megawatts
MWh	megawatt hours = 1 million watt hours
NG or n g	natural gas
nm	nanometer
Nm^3	cubic meters at standard conditions of temperature and pressure (20° C and 1 atmosphere)
NO_x	nitrogen oxide
O_2	oxygen
P	pressure
PC	personal computer
ppm	parts per million
psig	pounds per square inch (gauge)
R	ruble
RMA	Resource Management Associates of Madison, Inc

RPM or rpm	Revolutions Per Minute
s	second
SO_2	sulfur dioxide
sq ft	square feet
T	temperature
Tcal	teracalorie = 1 trillion calories = 3 968 billion BTU
therm	volume of natural gas 100 cubic feet, 100,000 BTU
TPS	Thermal Power Station
TWh	TeraWatt hour(s) (10^9 kWh)
U S or US	United States
V	volt(s)
VA	volt-amps
VArs	volt-amps (reactive)
VSD	variable speed drive
$US	United States Dollars
yr	year

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APPENDIX I
Specifications of Equipment to be Installed

Combustion Analyzer Specification

Two - Bacharach Model CA300NSX combustion analyzer on power supply of 220 V, with accessories

Fuels capability

Natural Gas (Russian composition)
#5 fuel oil
Coal
Blast furnace gas
Coke gas
Mixes of above gasses

Measurement Capability

k O_2, CO, NO_2, SO_2, Temperature

Calculation Capability

Combustion efficiency
CO_2 concentration
Excess air ratio

Accuracy

NO_2 +/- 5% of reading
SO_2 +/- 5% of reading

Probes 12-inch and 48-inch, capable to handle temperature up to 1000°C
Sampling hose 20 feet minimum
Output Thermal printer in unit
Power supply Rechargeable battery

Manufacturer Bacharach
Model CA 300 NSXE N 24-8032

PROJECT IMPLEMENTATION COST ESTIMATE

ITEM	UNIT	QUANTITY	COST/UNIT $	TOTAL COST $
Economizer	each	1	12,500	12,500
Diverting Damper Tee Section 16"	each	1	3,000	3,000
Booster Pump	each	1	800	800
2" sch 40 steel pipe w/ 1" fiber-glass insulation	linear feet	100	8	800
2" Check Valve	each	1	330	330
2" Gate Valve	each	3	200	600
1/2" Gate Drain	each	2	100	200
2" Circuit Setter	each	1	150	150
Differential pressure meter	each	1	560	560
Draft inducer	each	1	3,000	3000
2" pipe fittings	each	10	50	500
Total				22,400

It is assumed that some local materials, such as ducts, wiring, thermal insulation will be provided by facility The labor for all installation will be provided by facility also

Heat Exchanger Specifications

Suppliers
Combustion Systems
Tel (414) 548-3950
Fax (414) 548-0146
Contact Person Moe Morin

Cain Industries Heat Recovery Systems
Tel 1-800-558-8690
Fax (414) 251-0118

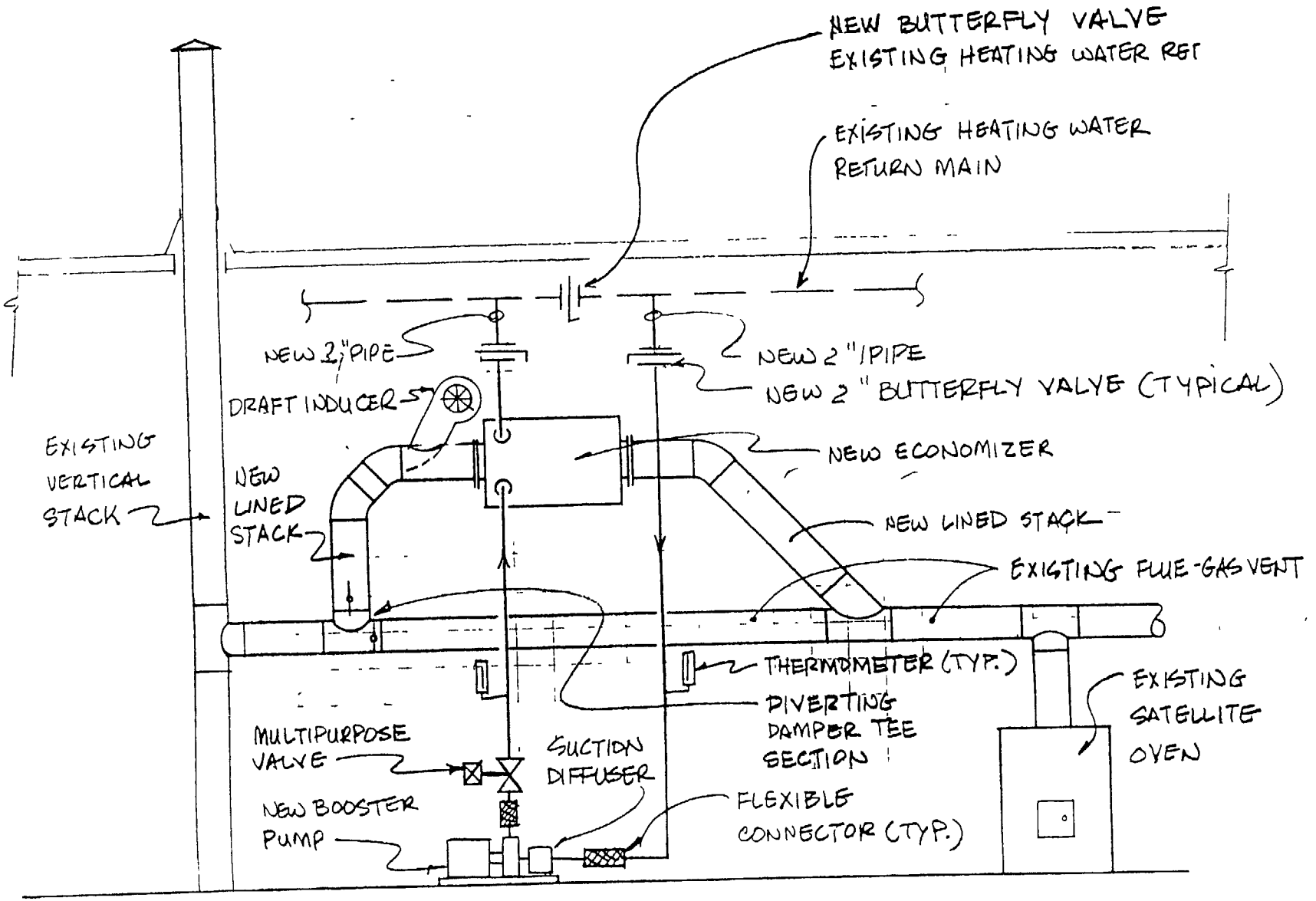
See Following Diagram

Maximum temperature of exposure = 1,500 F
Gas Temperature in = 1043 F
Gas Temperature out = 318 F

Heat extracted from flue gas = 1 44 MMBtu / Hour

Furnace input fuel rating = 45 cubic meters of natural gas per hour
Heat content of local natural gas = 900 Btu / cubic meter

Exhaust stack diameter = 14 inches



SCHEMATIC SHOWING PROPOSED ECONOMIZER

NO SCALE

SPECIFICATION OF
FLUE GAS RECIRCULATION (FGR) HEAT RECOVERY BURNERS

QUANTITY 2 (two) complete units

Units are to be packaged so that the plants only responsibility is to provide installation of electrical supply, gas supply, burner, and tap into flue gas stack All other equipment and instructions necessary for startup are to be included by the vendor

As part of this project, all installation and maintenance manuals are to be translated into the Russian Language by a technical translator

Manufacturer of this equipment
Industrial Combustion
Division of Aqua-Chem, Inc
351 - 21st Street
Monroe, WI 53566-2798 (USA)
Phone (608) 325-3141
Fax (608) 325-4379
Technical Contact Kim Black

Distributor of this equipment
R Mueller Service and Equipment Co
1412 13th Street
Monroe, WI 53566 (USA)
Phone (608) 328-8362
Fax (608) 328-8369
Technical Contact Bill Bruce

Characteristics of Each Burner Consist of

FUEL	Natural Gas @ 900 Btu / cubic foot
FIRING RATE	5 MMBtu / hour

A) CONTROLS
1 240 volt, single phase, 50 hertz
2 Burner mounted control cabinet
3 Motor starters
4 Signal lights
5 Full modulation with characterized (Cam) Trim
6 Flame safeguard to be compatible with molten glass in combustion chamber
7 Combustion air proving switch

B) MAIN GAS SYSTEM
1 Butterfly rate control valve
2 Motorized valve with closure interlock
3 Lubricated plug valves
4 High and low gas pressure switches
5 Pressure regulator

C) FLUE GAS RECIRCULATION (FGR) CONTROL SYSTEM
1 FGR high temperature control valve
2. FGR purge assemble
3 Blast tube high temperature switch

D) GAS PILOT SYSTEM
1 Gas-electric interrupted pilot
2 Shutoff cock
3 Separate pilot regulator and valve

E) OTHER
1 Hinged, swing-away air housing
2 Burner blower motor
3 Cast aluminum impeller
4 Rotary type air damper with silencer and FGR flanged connection
5 Burner mounting flange
6 High temperature firing head assembly
7 Refractory combustion cone
8 FGR piping to withstand 2000 F for a stack connection 20 feet from burner location

The supplier is to furnish burners which are completely assembled, wired and factory tested The complete system shall be listed by Underwriter' Laboratories and have individual U L Labels on the major components, i e purge system, flue gas recirculation metering valve, panel, proving the total system to be certified

The burner manufacturer shall have installed at least 300 system with at least 200 of them in service for two years or more

The burner shall be a high radiant multi-port type for gas, capable of burning 5,540 cubic feet (157 cubic meters) of natural gas per hour at 900 Btu per cubic foot (local heat content) at a pressure of not greater than 1 psia the inlet of the gas control train, with a minimum turndown ratio of 10 to 1

The burner shall be capable of firing against a furnace pressure from a negative 05 inches to a positive 4 0 inches of water column without a reduction in capacity or

efficiency The blower motor is to be of sufficient size, single phase, 50 Hz, 240 volts, directly driving a self cleaning impeller to supply all air for combustion The impeller shall be warranted in writing by the burner manufacture for a minimum of five years Combustion air volume shall be controlled by a multiple-blade inlet damper Each damper blade shall be separately moveable in relation to other blades Neither fuel lines or electrical wiring shall require disconnection when opening the hinged assemble Removal of the burner diffuser does not require removing the burner from the boiler

Means shall be provided to purge the Flue Gas Recirculation (FGR) line with at least 10 air changes from the FGR connection at the burner assembly towards and into the boiler stack, prior to pilot and main flame ignition This FGR purge cycle shall be proven with a pressure switch installed in the FGR line as well as with an electrical interlock on the purge blower motor starter to insure that combustible gases accumulated in the FGR line are exhausted safely This purge system shall shut down upon main flame establishment

Equipment that does not utilize either an FGR purge system or an FGR 100% safety shutoff valve to isolate any possibility of recirculating combustible gases through the boiler via the FGR system during prepurge shall require documentation from the equipment manufacturer, signed by and office of that company, proving and guaranteeing that under no circumstances will there be any possibility of there being combustible gases in the explosive range present in the boiler or FGR system at the time of ignition

Systems which use a separate FGR fan assembly to force FGR into the burner and/or combustion chamber during normal burner "run" shall not be acceptable

All FGR components, specifically the electrical control cabinet, FGR purge assemble, and FGR control valve shall be U L Listed and bear the U > Listing Mark A U L Approved flue gas control valve shall be provided to insure proper FGR flow into the burner firing head Listed blast tube temperature switch shall be provided to insure that the temperature limits of all internally mounted component are not exceeded

FUEL PIPING TRAINS
As a minimum, all fuel trains shall meet the requirement of UL-795 and 296 for the respective burner firing range (Option, can specify I R I , NFPA-85, FM, and CSD-1, or any local codes)

Main Gas Train
2 manual lubricated plug cocks
1 main gas pressure regulator
2 motorized automatic valves (1 with proof of closure)
1 butterfly valve with 14 point cam trim

1 high gas pressure switch
1 low gas pressure switch
1 normally open vent valve solenoid type
1 pressure gauge 0 to 30 kg/cm^2

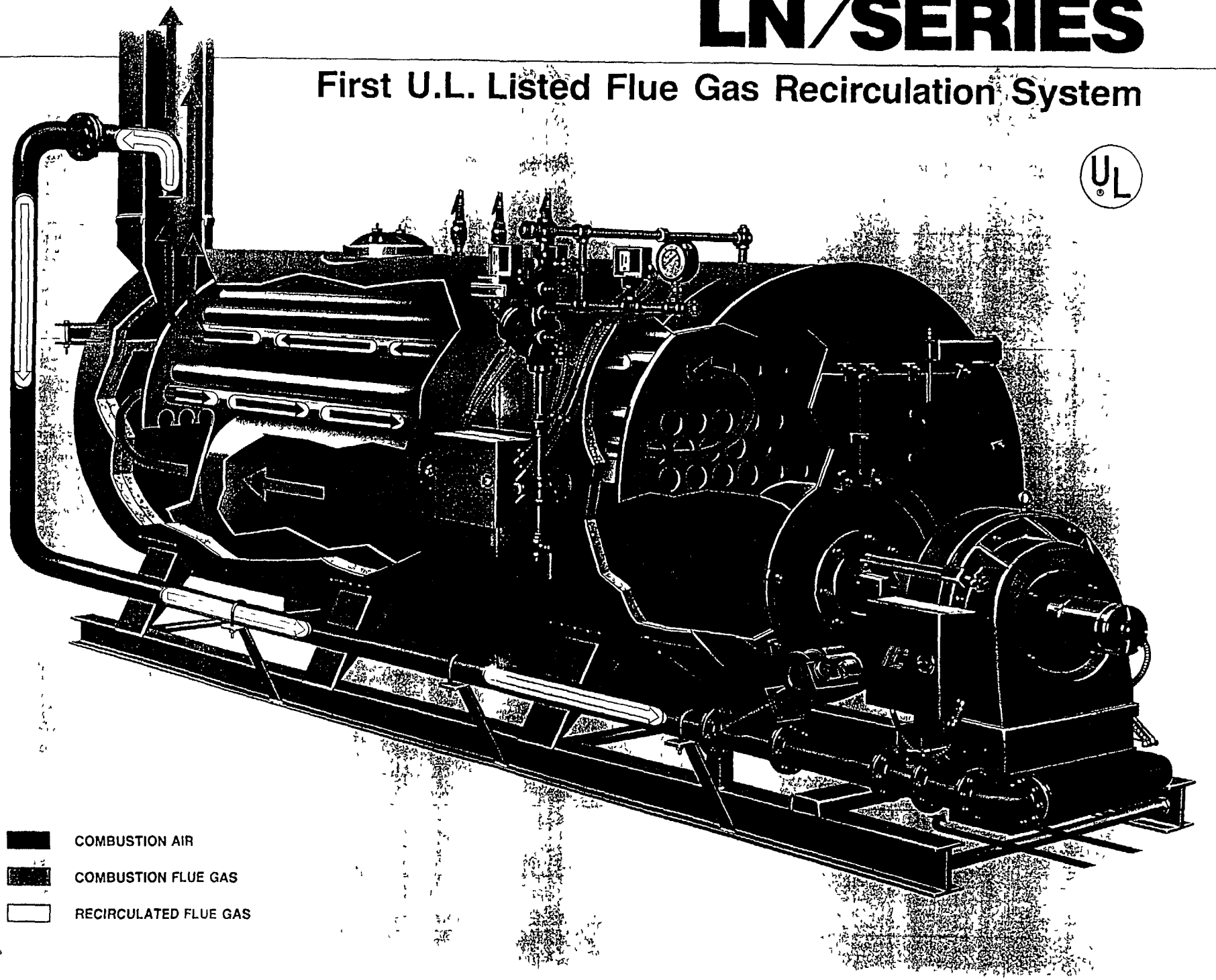
Pilot Train
2 manual shut off cocks
1 pilot pressure regulator
2 automatic shot off valves solenoid type
1 pressure gauge 0 to 15 kg/cm^2
1 normally open vent valve solenoid type

BURNER CONTROL CABINET
The NEMA 1 control panel shall bear the Underwriters' Laboratory listing mark and include an electronic combustion flame safeguard which is compatible with molten glass being in the combustion area, motor starters with overload eaters and 3-leg protection for all 3-phase motors, 6,000 volt gas ignition transformer, operating switches, and color-coded wiring The Maine entrance buss, single drop and fuses shall be available for all 3-phase motors The control circuit shall be 240 volts, 50 hertz, single phase The control cabinet shall incorporate the following Six (6) Indicating light Power ON, Call for Heat, Ignition, Main Fuel, Flame Failure, and one (1) 4" Alarm Bell with automatic reset silencing switch

The combustion control system shall incorporate single point positioning electronic modulation with a manual / auto switch and 135 ohm potentiometer From a directly driven common jackshaft, each fuel metering device shall be cam operated with 14 point adjustment, to insure precise metering of fuel to air throughout the modulation range The cam trim assemblies shall be listed by Underwriters' Laboratories

LN/SERIES

First U.L. Listed Flue Gas Recirculation System



Capacities and Specifications

LNM/SERIES 3

Burner Size	14	22	25	28	30	34P	42P	54P	63P	84S	84P	105P
Oil Input (U.S. gph)	8 6	13 6	15	16 8	18	21	24	30	38	45	53	60
Gas Input (Btu/hr x 1000)	1,200	1,900	2 100	2,350	2,520	2 940	3 360	4 200	5 250	6,300	7,350	8,400
Boiler Horsepower	29	45	50	56	60	70	80	100	125	150	175	200
Impeller Motor Horsepower	1/2	1/2	1	1	1	2	2	3	3	5	7 1/2	7 1/2
Air/Oil Metering Unit Horsepower	3/4	3/4	3/4	3/4	3/4	1	1	1	2	2	2	2

LND/SERIES 3

Burner Size	42P	54P	63P	84S	84P	105P	145S	145P	175P	210P	252P	300P
Oil Input (U.S. gph)	24	30	38	45	53	60	75	90	105	120	150	180
Gas Input (Btu/hr x 1000)	3,360	4,200	5,250	6,300	7,350	8,400	10 500	12,600	14 700	16,800	21,000	25,200
Boiler Horsepower	80	100	125	150	175	200	250	300	350	400	500	600
Impeller Motor Horsepower	3	5	5	5	7 1/2	10	15	15	20	25	30	40
Compressor Motor Horsepower	3	3	3	3	3	3	5	5	5	5	7 1/2	7 1/2
Metering Unit Horsepower	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	3/4	3/4	3/4

Notes

1/ Firing rates based on altitudes to 2000 ft. above sea level. For firing rates at higher altitudes, consult factory
Gas input based on 1000 Btu/cu ft and .65 specific gravity, oil input based on 140,000 Btu/gal

2/ Boiler overall efficiency of 80% estimated. Industrial Combustion does not guarantee overall boiler efficiency.

3/ Furnace pressure, furnace dimensions and required NOx emissions may allow higher firing rates than shown above, consult factory

Factory Authorized Sales and Service

Type of fuel determines the model designator	
MODEL	FUEL
LNMG	GAS
LNMM	LIQUID FUEL
LNMMG	GAS/LIQUID FUEL
LNME	LIQUID FUEL
LNMEG	GAS/LIQUID FUEL
LNDG	GAS
LNDL	LIQUID FUEL
LNDLG	GAS/LIQUID FUEL
LNDM	LIQUID FUEL
LNDMG	GAS/LIQUID FUEL
LNDE	LIQUID FUEL
LNDEG	GAS/LIQUID FUEL

INDUSTRIAL COMBUSTION
DIVISION OF AQUA-CHEM, INC
351 21st Street - Monroe, Wisconsin 53566-2798

SPECIFICATION OF EQUIPMENT FOR ENERGY MANAGEMENT PROGRAM

Items included

a One non-contact ultrasonic flow meters - $8,000 total
b One Non-contact temperature measuring device - $3,500
c One 3- phase electrical meter with logging and downloading capability - $13,250 total
d One hot wire anemometer - $1400
e Laptop computer with plant energy management software - $4,000
f Laser printer - $3,000
g Energy management reference books - $500

Total = $33,650

COMPLETENESS OF EQUIPMENT SUPPORT MATERIAL AND MAINTENANCE

The equipment is to be packaged and delivered to the end user with all available support equipment including but not limited to, cables, computer download and upload interfaces, software, maintenance contracts, and calibration equipment such that it is self sustaining for a period of two years without any additional investment for these items Local suppliers or service facilities are not expected to be available during this time period In addition, the end user will not have budget to purchase additional goods or services

ALL EQUIPMENT MUST INCLUDE AS A MINIMUM:

I Internal design or appropriate adaptation equipment to recharge and operate equipment on 220 volt, 50 hertz power source, using Former Soviet Union standard 4 millimeter round prongs Ground pin to be supplied if necessary for safe operation

II All recharging equipment necessary to support battery operation of the equipment Recharging equipment must meet criteria (I) electrical requirements

III Sufficient rechargeable batteries to support 2,400 hours of intermittent audit usage over a two year period, with a minimum of two units

IV All available cables, connections, software, and adapters to interface with personal computer data storage and available uploading features

V Consumable parts and data output media for the equipment to be used 2,400 hours intermittently over a two year period

VI All costs associated with two years of recommended calibration and preventative maintenance Express shipping and full replacement loss insurance must be included from Ukraine to the nearest authorized service facility

VII Written translation of all manuals and safety information to the Ukrainian/Russian language

VIII All equipment must meet applicable United States standards

IX All portable equipment will be fitted with rigid reusable carrying cases to protect the equipment from frequent travel conditions Each unit of equipment is to be packaged in a single case unless weight exceeds 50 pounds, or a probe greater than 24 inches exists

a) ULTRASONIC FLOW METER AND TOTALIZER

(One complete unit is specified)

Repeatability	+/- 0 1% of full scale
Linearity	+/- 0 1% of full scale
System accuracy	+/- 5%
Rate readout	Metric units
Volume readout	Metric units
Flow rate range	Metric equal to 0 5 to 20 feet per second
Pipe diameters	15 to 2,000 mm (0 6 to 79 inches)
Totalizer	Metric units
Transducer	High temperature to 400 F (204 C)
Transducer cable	20 feet minimum
Capability	Must measure clear and suspended particle media
Power source	Rechargeable battery
Manufacturer	Dynasonics, Inc
Model	M3-902 OR EQUAL

b) INFRARED NON-CONTACT THERMOMETER (MIDRANGE TEMPERATURES)

Wahl Brand Infrared thermometer, model DHS-26XL1 or Equal

Range	0 to 2,000 degrees Fahrenheit or -20 to 1,000 degrees Celsius
Accuracy	+ or - 0 3% of reading
Aiming	LCD laser sight
Emissivity	adjustable
Scale	Fahrenheit and Celsius switchable
Resolution	1 degree
Warranty	3 years
Power	battery for portability
Options	220 volt rechargeable battery pack
Pricing	$3,000 base unit
	$ 400 rechargeable battery pack
	$ 100 shipping

	$3,500 Total

c) THREE PHASE ENERGY ANALYZER

(One complete unit is specified)

Quantities Monitored
Kilowatt Hours
Kilowatts
RkVAH
kVA
Power Factor
Volts
Amps
Harmonic Analysis

Data Storage	All quantities monitored
Memory	7 day recording of all parameters
Software	To display and print results in graphical format from PC
Display	LCD and Paper Tape Printer
Power supply	Rechargeable, field replaceable

Current Transformers

range #1	0 to 10 amps
range #2	0 to 150 amps
range #3	15 to 300 amps
range #4	50 to 1,000 amps
range #5	100 to 3,000 amps

Manufacturer	Dranetz
Model	8,000 OR EQUAL

d) HOT WIRE ANEMOMETER

(One complete unit is specified)

Velocity range, fpm	0 -- 300, 0 -- 6000
Temperature range	0 -- 250F
Static pressure range	0 -- 5 in H_2O
Probe operating temperature "HT" model	from -55°C (-67F) to +250°C (+482F)
Accuracy of velocity measurement	+ or - 2 - 4%
Accuracy of pressure measurement	+ or - 2%
Accuracy of temperature measurement	+ or - 2%

Power	Nickel-cadmium battery with 230 V AC, 50 HZ charger, operates up to eight hours
Manufacturer	Kurz and Davis-Instruments
Model	444 OR EQUAL
Pricing	$929 base unit $305 High temperature probe $166 shipping ---------- $1,400 Total

e) Laptop (Notebook) Computer

Bus architecture	486
Processor speed	33 Megahertz
Ram	4 Megabyte
Hard drive	200 Megabyte minimum
Floppy drive	3 5 inch, 1 44 MB
Keyboard	85 key full size
Display	9 5 inch dual matrix color
Battery	Rechargeable
Battery life	3 hours continuous use minimum
Communication	Fax/modem installed internal 9600/2400 with V 42bis
PCMCIA slots	Two of type II
Pointing device	Built in trackball
Pre-installed software	Windows version 3 1 Lotus 1-2-3 for windows Winfax Pro for windows
Pre-formatted disks	100 each, 3 5 inch, 1 44 MB
Miscellaneous	Inverted "T" cursor control Ports for external VGA monitor, keyboard, and mouse connection AC adapter (240 volt, 50 hertz) with Former USSR 4mm round plug
Manufacturer	IBM
Model	Thinkpad 750C

f) LASER PRINTER

Resolution	600 dpi
Speed	8 pages per minute minimum
Memory	4 Megabytes
Paper format	A4
Emulation	HP PCL 5

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Interface	Centronics
Manufacturer	Hewlett - Packard
Model	HP 4 OR EQUAL

g) ENERGY MANAGEMENT REFERENCE BOOKS
(One of each book - translation not required)

I Title Energy Conservation Techniques for Engineers
Author Harry B Zackrison, Jr

ii Title Energy Conservation Through Control
Author F G Shinskey, Foxboro Company

iii Title Energy Efficient Electric Motors and Application
Author Howard E Jordan, Reliance Electric Company

iv Title The Energy Saving Guide
Author G Helcke

v Title Energy for Industry
Author P W O'Callaghan

Supplier OMEGA Vol 1 Scientific and Technical Books
Pages CE-33, MS-42, EE-44, MS-34, MS-34 OR EQUAL

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