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BURNS AND ROE ENTERPRISES, INC.

Audit Report
KOMMUNAR/ZAZ CAR PLANT
ZAPOROZHIA, UKRAINE

FINAL

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FOSTER WHEELER USA CORPORATION
CLINTON, NEW JERSEY, U.S.A.

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Delivery Order #6:
Energy Efficiency and Reliability for the Ukraine
Task 3 - Industrial Energy Efficiency

KOMMUNAR/ZAZ Car Plant
ZAPOROZHIA, UKRAINE

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Preface

The work described in this report has been carried out by FOSTER WHEELER USA CORPORATION (FWUSA) of Clinton, New Jersey, 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 CCN-0002-1-00-3154-00.

This is a working document published informally by FWUSA. 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.

Table of Contents

1 0 EXECUTIVE SUMMARY 1

2.0 PURPOSE OF AUDIT . . . 5

3 0 FACILITY BACKGROUND . 6
- 3 1 Description of Facility . . 6
- 3 2 Product Background . . 7
- 3.3 Viability of Facility . 7
- 3.4 Energy Conservation History . 8
- 3.5 Facility Energy Use 10
  - 3 5 1 Consumption 10
  - 3 5 2 Energy-Using Systems . 12
  - 3.5 3 Energy Costs . . 14

4 0 SYSTEMS AUDITED - SHORT TERM RECOMMENDATIONS 15
- 4.1 Boilers 15
- 4 2 Water Heaters 19
- 4.3 Steam System 20
- 4 4 Condensate System 22
- 4 5 Compressed Air System 23
- 4 6 Elecgtrical System 25
- 4.7 Energy Management and Training 27

5 0 SYSTEMS AUDITED - LONG TERM RECOMMENDATIONS 31
- 5 1 Electrical System . . 31
- 5 2 Steam System . 31
- 5 3 Condensate System 32

6 0 TRAINING ACCOMPLISHED . . . 34

7 0 IMPACT OF SAVINGS . . . 35

8 0 RESULTS OF FOLLOW - UP VISIT . . 36
- 8.1 Visit Objectives 36
- 8 2 Main Energy Conservation Opportunities (ECOs) during 1995 36
- 8 3 Status of Plant During July, 1997 Visit . 37
- 8 4 Accomplishments During Visit 37
- 8.5 Work Needed to Complete Implementation . 38
- 8 6 Lessons Learned 39

List of Tables

Table 1 Summary of Energy Conservation Opportunities (ECOs) . 3
Table 2 Boiler Descriptions . 15
Table 3 Water Heater Characteristics . 20

Appendices

APPENDIX "A"
Energy Conservation Opportunities (ECO's)
Savings Calculations, Implementation Costs, Specifications

APPENDIX "B"
Photographs of Facility and Equipment

APPENDIX "C"
Plant Energy Consumption History

APPENDIX "D"
World and Local Energy Prices

APPENDIX "E"
List of Contacts Made in Facility

APPENDIX "F"
Abbreviations and Units Conversions

1.0 EXECUTIVE SUMMARY

Introduction

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 Foster Wheeler USA Corporation of Clinton, New Jersey (USA); the other three audits were conducted by Burns & Roe Enterprises and Resource Management Associates (RMA). This report details the findings of the Foster Wheeler energy audit performed at the KOMMUNAR/ZAZ Car Plant, located in Zaporozhia, Ukraine.

The five industrial audit sites were selected under previous activities within this Delivery Order. This selection process included working with Ukrainian agencies and the Ukrainian IDEA Staff to identify the largest and most intensive electrical energy consuming sectors. Plants typical of each sector were suggested for audits. Site visits to each plant were coordinated by the IDEA staff; team leaders from Foster Wheeler and RMA reviewed these facilities in order to select the five most appropriate sites. Each facility was evaluated using a numerical ranking form, and the five plants scoring the highest were selected. The chosen sites were then notified that they had been selected to participate in the energy audits and demonstration activity. In addition to the KOMMUNAR/ZAZ Car Plant, the following four plants were selected: Kiev Artistic Glass Plant in Kiev; Zaporozhia Coke and Chemical Plant in Zaporozhia; Strojindustrial Building Materials in Kiev; and Donetsk Metallurgical Plant in Donetsk. Following notification, audit schedules were coordinated, and the audits conducted.

The audit team of Dr. Howard Feintuch and Dr. James Stumbar, of Foster Wheeler USA Corporation of Clinton, New Jersey spent the period of March 1 through March 12, 1995 in Zaporozhia, Ukraine. During this period, they performed an energy audit, of the KOMMUNAR/ZAZ Car Plant located in Zaporozhia. This report describes the plant, the energy using systems audited, and recommendations for energy conservation opportunities (ECO's), both for short term no cost/low cost measures and for longer term higher cost investment measures.

The KOMMUNAR/ZAZ Car Plant, is one of the oldest enterprises in the Ukraine. It currently employs 20,000 employees. It is a state owned plant which was originally established in 1863 to produce shovels and agricultural equipment. In 1958 the plant's design was reconverted by the State Agency for Automotive Design to produce cars, rather than agricultural machinery.

1.0 EXECUTIVE SUMMARY

Introduction (continued)

The Plant, currently produces cars and pick-up trucks, and in the future will produce mini-buses and mini-trucks. Currently, two models of cars are produced, the 1102 and the 1105. In 1994, the plant produced a total of 91,362 vehicles or an average of 7,614 vehicles per month. The plant's design capacity, however, is 300,000 vehicles per year. The capacity of the plant is limited by the availability of the components needed to produce the finished products. For 1995 the plant plans to produce an average of 8,000 vehicles per month.

Principle Findings

Several energy conservation opportunities (ECO's) were identified for short term no cost/low cost measures and for longer term higher cost investment measures. Sixteen (16) ECO's were identified and are summarized in Table 1. Most of these ECO's have attractive paybacks, both on world and on local energy prices. Only the three electrical ECO's #'s 10, 13, and 14 and condensate collection ECO #16 are unattractive.

ECO's 01, 02 and 09 contain energy savings equipment and instrumentation related to combustion efficiency improvement and to electrical measurements. It is recommended that USAID assist the plant in starting its energy conservation program by purchasing for them the equipment and instruments contained in these three ECO's for an estimated cost of $ 98,700. Annually, these ECO's would save $ 734,300 based upon local prices and $ 1,689,200 based upon world prices. Energy savings for these ECO's are 182.6 billion Btu (192,700 GJ) or 5,259,000 m^3 of natural gas and 26.0 million kWh electricity.

Please note that totals are not given for the columns in Table 1, because some of the numbers presented are included in more than one of the ECO's listed.

Table 1 Summary of Energy Conservation Opportunities (ECO's)

ECO #	DESCRIPTION	ANNUAL FUEL SAVINGS m^3/yr OF NATURAL GAS (ELEC-TRICITY)	ANNUAL ENERGY SAVED	ANNUAL COST SAVINGS (US $)		ESTIMATED PROJECT COST (US$)	SIMPLE PAYBACK WORLD ENERGY PRICES	SIMPLE PAYBACK LOCAL ENERGY PRICES
				WORLD ENERGY PRICES	LOCAL ENERGY PRICES			
01	Purchase Portable Boiler Efficiency Measurement Device	2,940,000	102 billion Btu (107,700 GJ)	217,600	185,200	$ 7,000	12 days	14 days
02	Install Automatic Combustion Controls, Adjust Burners, and Clean Heat Transfer Surfaces	2,319,000	80 6 billion Btu (85,000 GJ)	171,600	146,100	$ 78,600	5 5 months	6 5 months
03	Isolate Nonoperating Boilers for Shutdown Greater Than Two Months to Reduce Excess Air	449,000	15 6 billion Btu (16,500 GJ)	33,200	28,200	$ 2,700	30 days	34 days
04	Repair Insulation on Boiler Feed Water Lines	15,700	546 million Btu (576 GJ)	1,162	990	$ 427	2 3 months	2 75 months
05	Fix Rather Large Leak from Steam Valve in Main Building	12,000	0 42 billion Btu (440 GJ)	1,830	630	$ 100	20 days	1 9 months
06	Install Automatic Flow Controllers on Large Users of Steam	439,000	15 3 billion Btu (16,100 GJ)	66,200	22,800	$ 93,300	1 4 years	4 years
07	Minimize Vent Losses on Opened Condensate Collection System	120,000	4 2 billon Btu (4,400 GJ)	18,400	6,300	$ 500	10 days	29 days
08	Install Automatic Flow Controllers on Large Users of Compressed Air	(3,100,000 kWh)	3 1 million kWh	155,000	48,100	$ 72,100	6 months	1 5 years

Table 1 Summary of Energy Conservation Opportunities (ECO's)

ECO #	DESCRIPTION	ANNUAL FUEL SAVINGS m^3/yr OF NATURAL GAS (ELEC-TRICITY)	ANNUAL ENERGY SAVED	ANNUAL COST SAVINGS (US$)		ESTIMATED PROJECT COST (US$)	SIMPLE PAYBACK WORLD ENERGY PRICES	SIMPLE PAYBACK LOCAL ENERGY PRICES
				WORLD ENERGY PRICES	LOCAL ENERGY PRICES			
9	Shut Down Equipment That Does Not Always Need to Run	(26,000 MWh)	26,000 MWh	1,300,000	403,000	$14,100	4 days	13 days
10	Reduce Excess Lighting and Improve Dimly Lit Areas in Certain Parts of Automobile Final Assembly Building	(20,000 kWh)	20,000 kWh	1,000	310	$25,000	25 years	81 years
11	Institute Improved Energy Management Procedures	10,938,000	380 billion Btu (400,900 GJ)	2,000,000	718,000	Negligible	Immediate	Immediate
12	Institute Energy Conservation Training of Plant Personnel	5,470,000	190 billion Btu (200,500 GJ)	1,000,000	359,000	Negligible	Immediate	Immediate
13	Improve Low Power Factor Caused by Induction Motors During Robotics Welding	(8,300,000 kvar)	8 3 million kvar	49,900	15,800	$75,000	1 5 years	4 8 years
14	Install Variable Speed Drive on One or More Turbo Compressor Motors	(3,400,000 kWh)	3 4 million kWh	168,500	52,200	$1,000,000	5 9 years	19 1 yearrs
15	Add or Replace Non-Operating Steam Traps	2,445,000	84 9 billion Btu (89,600 GJ)	166,400	126,500	$107,600	7 8 months	10 2 months
16	Collect Additional Condensate and Recycle to Boilerhouse	612,000	21 1 billion Btu (22,400 GJ)	91,700	31,200	$206,000	2 2 years	6 6 years

2.0 PURPOSE OF AUDIT

The purpose of this audit is to investigate the large consumers of energy within the plant and to identify energy conservation opportunities (ECO's) for short term no cost/low cost measures and for longer term higher cost investment measures. This will improve plant energy efficiency and reduce the current overall consumption of energy within the plant in its various forms.

The KOMMUNAR/ZAZ Car Plant was selected as a critical energy intensive facility important to the economy of the Ukraine. It is recognized as having many opportunities to reduce energy consumption by improving efficiency of energy utilization.

The plant was selected in October of 1994, following a survey in which many different types of plants were visited throughout the Ukraine for the purpose of selecting the five best candidates.

3.0 FACILITY BACKGROUND

3.1 Description of Facility

The KOMMUNAR/ZAZ Car Plant, located in Zaporozhia, Ukraine, is one of the oldest enterprises in the Ukraine. It currently employs 20,000 employees. It is a state owned plant which was originally established in 1863 to produce shovels and agricultural equipment.

In 1958 the plant's design was reconverted by the State Agency for Automotive Design to produce cars, rather than agricultural machinery and in 1960 automotive production began. In subsequent years various expansions and modifications took place:

1961:	Boilers Converted from Coal to Gas
1974 to 1978:	Various New Work Shops
1988:	New Work Shop for Welding (using Robotics)
1992:	New Finishing Line (Conveyors and Painting)

In 1989, the plant produced its 3 millionth car.

The plant contains approximately one hundred (100) buildings. These are related to the various steps which take place in the production of the vehicles. These are also related to the production and supply of the utilities such as steam, compressed air and hot water that are needed in the various steps of the production process. Large quantities of electricity are also consumed.

Steam is a major utility and in the boilerhouse there are seven (7) boilers, each built in the 1950's. Each boiler is capable of producing 14 metric tons per hour of 8 bar steam by firing natural gas. Mazut is used as a standby fuel. In the winter five (5) boilers are normally used. In the summer three (3) to four (4) boilers are used. In the same boilerhouse, three (3) water heaters are used to supply hot water throughout the plant. One water heater was built in 1967, another in 1985 and the last in 1989.

There are four (4) stations for supplying compressed air. One has four (4) compressors built in 1956. Another has five (5) compressors also built in 1956. A third has four (4) compressors built in 1970. The last has three (3) compressors built in 1989.

3.0 FACILITY BACKGROUND

3.2 Product Background

The KOMMUNAR/ZAZ Car Plant, produces cars and pick-up trucks, and in the future will produce mini-buses and mini-trucks. Currently, two models of cars are produced, the 1102 and the 1105. In 1994, the plant produced a total of 91,362 vehicles or an average of 7,614 vehicles per month. The plant's design capacity, however, is 300,000 vehicles per year.

The capacity of the plant is limited by the availability of the components needed to produce the finished products. For 1995 the plant plans to produce an average of 8,000 vehicles per month.

The plant typically operates five (5) days a week, corresponding to approximately 260 days per year, with two (2) eight (8) hour shifts per day, but sometimes less than this when components are not available. The two shifts typically operate from 7:00 a.m. to 3:30 p.m. and from 3:00 p.m. to 11:40 p.m.

The cars sell on the average for the equivalent of $ 2,800 U.S. and at that price the plant can sell as many cars as it is able to produce. The top-of-the-line ZAZ car sells for about $ 4,800.

Currently about 3.6 percent of production is exported outside of the Ukraine and the remaining 96.4 percent is sold domestically. During our visit we watched a production run being made for export to Hungary of red cars and of blue cars.

3.3 Viability of Facility

The demand for the vehicles produced by the facility is currently very strong. Production is limited, however, by the availability of the component parts needed to produce the finished product. These component parts are produced by other companies outside the plant.

3.0 FACILITY BACKGROUND

3.3 Viability of Facility (continued)

At the current attractively low average price of $ 2,800 U.S. per car, it is expected that demand will continue to be strong. The current yearly production of 91,362 vehicles is, however, only 30.5 percent of the design capacity of the plant, which is rated at 300,000 vehicles per year. This must be improved without delay. At this point in time, the plan is to produce 8,000 vehicles per month for all of 1995. This would correspond to a total of 96,000 vehicles for all of 1995. This is still only 32 percent of design capacity.

Currently, approximately 3.6 percent of the plant's production is exported outside of the Ukraine. It is envisioned that this would increase if overall production would be higher.

Any and all increases in the cost of energy would have an adverse effect on the facility, since it would cause the average cost of the vehicles produced to increase.

3.4 Energy Conservation History

The plant has, in the past, attempted to implement various energy conservation measures, but in most cases have been impeded by a lack of hard currency and by difficulties encountered in their lack of energy management procedures.

The plant does not have a single individual who is responsible for energy conservation, but does have a committee known as the "Bureau for Energy Usage". The plant does not have any budget for energy conservation. It must instead make recommendations to the "Ruling Body" who then decides if the request has merit. It is extremely difficult to get approval from the "Ruling Body".

There currently is no criteria, such as payback or discounted cash flow, for making investments in the plant to conserve energy. Employees have received no training in the principles of energy conservation. Basic maintenance is performed, except where replacement parts are not available or where the implementation of the repair would be extremely costly.

3.0 FACILITY BACKGROUND

3.4 Energy Conservation History (continued)

An example of a energy conservation project which the plant has successfully implemented is the installation of a monitoring system which can measure electrical energy consumption on 64 points of the plant. On the other hand, the plant has never been given the budget to increase condensate recovery, 70 percent of which is currently discharged hot to the sewer.

3.0 FACILITY BACKGROUND

3.5 Facility Energy Use

3.5.1 Consumption

The types of energy used at the KOMMUNAR/ZAZ Car Plant are electricity, natural gas and mazut as a back-up boiler feed. It takes 44.0 GIGA-JOULES (41.7 million Btu) to produce one car. The principal energy source is electricity. Electricity accounts for 60.7 percent of energy usage in the plant and natural gas accounts for 38.7 percent. Mazut accounts only for 0.60 percent of the energy usage. This can be seen graphically on the pie chart on the following page.

The total plant electrical load is approximately 50 megawatts. All of the electricity is purchased from DNEPROENERGO who operate a 1,500 MW capacity hydroelectric plant nearby, as well as several thermal plants and a soon to be completed nuclear facility, all relatively nearby.

The KOMMUNAR/ZAZ Car Plant consumed the following amounts of energy in 1994:

Electricity

203,383,464 kWh

Natural Gas

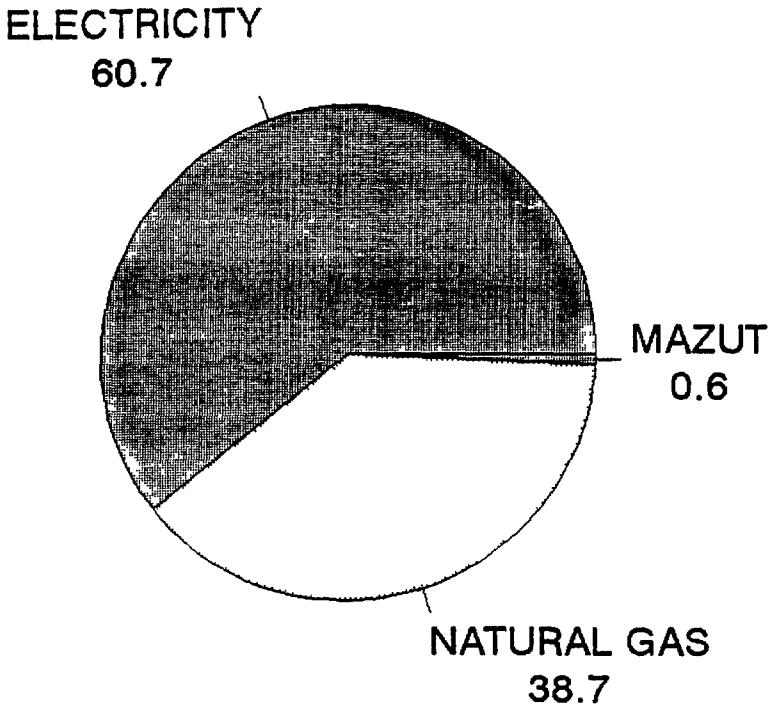
42,467 thousands of Meters^3

Mazut

592 metric tons

KOMMUNAR/ZAZ CAR PLANT

1994 FACILITY ENERGY CONSUMPTION



PERCENTAGE OF EACH ENERGY SOURCE USED IN 1994

3.0 FACILITY BACKGROUND

3.5 Facility Energy Use

3.5.1 Consumption (continued)

Appendix "C" shows that the highest consumption of electricity in 1994 was in the month of June when 18.57 million kWh was consumed. The lowest electrical consumption in 1994 was in the month of August when 15.54 million kWh was consumed. This represents a difference of 19 percent between high and low months. The month of June has the second highest monthly production rate of vehicles for the year. The month of August has the third lowest production rate for the year. So we see that electrical consumption and vehicle production are closely related.

Appendix "C" shows that the highest consumption of natural gas was in 1994 in the month of January, when 5,490 thousand meters^3 was consumed. The lowest consumption of natural gas in 1994 was in the month of September when 1,920 thousand meters^3 was consumed. The wide swing in these valves and the months in which they occurred indicate that the consumption of natural gas is more weather related than production related.

3.5.2 Energy-Using Systems

Boilerhouse/Steam System

The production of steam in the boilerhouse is a large consumer of natural gas and a small consumer of mazut, as a back-up fuel. There are seven (7) boilers, each capable of producing 14 metric tons per of 8 bar steam.

In the winter, five (5) boilers operate and in the summer three (3) or four (4). The steam produced in the boilerhouse is widely distributed throughout the entire plant site. Only 30 percent of the condensate produced by the steam recovered and returned to the boilerhouse. The remaining 70 percent is lost to the sewer.

3.0 FACILITY BACKGROUND

3.5 Facility Energy Use

3.5.2 Energy-Using Systems (continued)

Also in the boilerhouse, there are three (3) water heaters which produce hot water which is supplied throughout the plant.

Compressor Stations

The plant has four (4) compressor stations which supply compressed air throughout the entire plant. These stations consume large quantities of electricity. The largest station is station number three (3). This station has four (4) turbo-compressor, 1,500 KW each. This station normally has three (3) compressors operating. Station number four (4) has three (3) compressors, 625 KW each. Two (2) of these are normally operating.

Station number one has four (4) compressors, each 600 KW, with two normally operating. Station number two has five (5) compressors which are 300 KW each. Two are normally operating.

The highest users of the compressed air are for the pressing of metal, painting and welding.

Welding Operation

The welding operation is a large consumption of electricity. In the largest of the two (2), welding shops there are 165 robots all produced in Germany. Each of the robots consume 27 KW for movement and 100 to 150 KW kilovolt - amperes for welding. The induction motors which power the robots contribute towards a very poor power factor.

Auto Finishing Plant

The vehicles are completed in this part of the plant. The conveyors used in this operation use approximately 2,000 KW.

3.0 FACILITY BACKGROUND

3.5 Facility Energy Use

3.5.3 Energy Costs

The plant indicated that the cost of energy was continuously increasing. They were not able to give us any information on projections for future cost, but did give us some information on the previous costs of electricity. The following information is for their current costs:

Utility	Current Plant Costs
Natural Gas	$ 63.00 U.S. per 1,000 meter^3
Electricity	2,300 Ukrainian coupons/kWh or $ 0.0155/kWh*
	267,900 Ukrainian coupons per KW demanded or $ 1.81/KW demanded

Industrial enterprises with installed power of 750 KW and more pay for electricity in a 2-stage tariff.

That is:
1. Cost of electricity consumed.
2. Cost of electricity demanded.

Note: In the case of higher power usage (that exceeds the demanded figure) which is checked within a 30 minute interval, the plant must pay 10 times more than the normal rate for every extra KW used. The hours of 8:00 to 11:00 and 17:00 to 21:00 are the hours in which the higher power usage will result in penalty payments.

Mazut	6.5 Million Ukrainian coupons/metric ton or $ 43.92 per metric ton*

As a means of comparison, world and local energy prices may be seen in Appendix "D".

*Based on current exchange rate of 148,000 Ukrainian coupons, per U.S. dollar.

4.0 SYSTEMS AUDITED - SHORT TERM RECOMMENDATIONS

4.1 Boilers

There are seven (7) boilers, each capable of producing 14 metric tons per of 8 bar steam. Boiler 1 is currently out of service giving six boilers for steam production. Boilers 1 through 4 are identical Soviet-design DCV10/13 units manufactured in 1952 for coal firing. Boilers 5 through 7 are identical Soviet-design SHB10/13 units manufactured in 1955 for coal firing. All boilers were converted to natural gas with mazut backup in 1961. Boil feed water is supplied to the boilers through a single deaerator and two economizers. Maximum steam generation capability of these boilers is 98 metric tons/hour (T/hr). Because of differences in steam demand, the plant operates five (5) boilers in winter and three (3) boilers in summer. During the audit four (4) boilers were operating at about 52 T/hr steam rate due to unseasonable warm weather. Combustion air is not preheated but it is drawn from the top of the boilerhouse.

Table 2
Boiler Descriptions

Boiler Number	Steam Conditions			Feedwater Temperature (°C) Economizer in/out	Combustion Air Temperature (°C)	Fuel
	Flow (T/hr)	Pressure (bar)	Temperature (°C)			
1,2,3,&4	14	8 design 8 normal	175 saturated	103 130	ambient	Gas
5,6,&7	14	8 design 8 normal	175 saturated	103 130	ambient	Gas

The audit revealed two areas for improvements in the efficiency of the steam production cycle: 1.) recovery of condensate can be increased; 2.) incomplete combustion due to production of carbon monoxide can be eliminated. Combustion efficiencies, measured on March 9, downstream of Economizer 1 and Economizer 2 were only 66.1% and 66.4% due mainly to high levels of carbon monoxide. If carbon monoxide was eliminated, the efficiency of the boilers would be about 17% greater. Measured boiler efficiencies downstream of economizer 1 and 2 were 83.8% and 82.1% respectively without losses from unburned carbon monoxide. These measurements includes losses due to excess air plus 3% additional losses for heat transfer through the walls and heat lost in blowdown. Up to 4.4% additional efficiency improvements may

be obtained if the excess air were controlled more effectively. Isolation of Boiler 1 and other nonoperating boilers should improve efficiency by about 2%. Due to the relatively low stack temperature, addition of an air preheater is not economically justified.

Boiler feed water is treated in sulfidized coal ion exchangers. The water is treated to less than 10 μg/kg hardness. The beds are regenerated with a NaCl brine. Treated water at 17 to 25 °C is sent to an atmospheric type deaerator (0.2 bar operating pressure) which operates at 103 - 104 °C. Venting of steam from the deaerators seems to be acceptable based upon visual observations. Continuous blowdown is high at 5% and heat is recovered to heat the raw feed water.

The operators run the boilers manually. They use a series of operating charts to set fuel control valve and air damper positions. There are no oxygen analyzers. High carbon monoxide levels and high excess air levels measured during the plant audit show that these boilers would benefit from combustion gas monitoring instruments and automatic control.

The project team and plant identified four energy conservation opportunities (ECO) applicable directly applicable to the boilers. These consisted of the purchase of a portable efficiency measurement device, installation of automatic boiler controls on boiler 2, isolation of nonoperating boilers when shutdown for extended time periods and repair of insulation on the boiler feed water piping. All of these were low cost or no cost opportunities.

Energy Conservation Opportunity #1 - Purchase Portable Boiler Efficiency Measurement Device

A portable boiler efficiency measuring device will permit operators to adjust the combustion to reduce episodes of carbon monoxide (CO) generation. Unburned fuel losses become significant when CO concentrations exceed 100 to 300 parts per million by volume (vppm) and CO concentrations exceeded 3,000 vppm. Unburned CO and excess oxygen cause an estimated 198 billion Btu (209,000 GJ). The estimated energy savings from the use of this instrument is 102 billion Btu (107,700 GJ) annually. This provides $185,200 savings based upon local prices and $217,600 savings based upon world wide prices. The estimated cost of the instrument is $7,000. The calculations show

a rapid payback for this instrument 14 days based on local prices and 12 days based on worldwide prices. **The audit team recommends that USAID purchase this instrument — a Bacharach Model CA300NSX Combustion Analyzer — for the plant.**

See Appendix "A" for relevant calculations and supporting data.

Energy Conservation Opportunity #2 - Install Automatic Combustion Controls, Adjust Burners, and Clean Heat Transfer Surfaces

Automatic combustion controls should enable the burners to operate with much lower excess air and prevent carbon monoxide formation. The plant intends to convert one boiler to automatic control. This boiler would be operated to take all reasonable changes in load, the remaining boilers on manual control would be kept at a constant steam outputs. This scheme would prevent formation of carbon monoxide by helping the plant to maintain the proper fuel/air ratio during and after steam load changes. Unburned CO and excess oxygen cause an estimated 198 billion Btu (209,000 GJ). The estimated energy savings from the use of this instrument is 80.6 billion Btu (85,000 GJ) annually. This provides $ 146,100 savings based upon local prices and $ 171,600 savings based upon world wide prices. The estimated cost of the project is $ 78,600 for the equipment to be paid for by USAID. This equipment will be installed by the plant. The calculations show a rapid payback for this project: 6.5 months based on local prices and 5.5 months based on worldwide prices.

For maximum benefit for the project, the burners on all boilers should be inspected and adjusted to ensure good mixing of the air and fuel and heat transfer surfaces should be checked for fouling. Combustion measurements show that carbon monoxide appears at excess oxygen levels of 2.7% to 6.0% depending on the boiler. Assuming minimal air leakage into the boiler settings, properly adjusted burners burn natural gas at 1.5% to 2.5% excess oxygen without excessive carbon monoxide generation.

4.1 Boilers (continued)

Boiler 3 and boiler 4 have higher flue gas temperatures than boiler 2. Heat transfer in these boilers is less effective than in boiler 2. Fouling of heat transfer surfaces from dust in the combustion air is a possible cause of these differences. Boiler heat transfer surfaces should be inspected for external fouling. If none is found, acid cleaning of the internal tube surfaces should be considered.

Implementation of this energy conservation opportunity is recommended because of the rapid payout at approximately 6 months. The audit team recommends that U.S. AID provide the money to purchase automatic controls for Boiler 2.

See Appendix "A" for relevant calculations and supporting data.

Energy Conservation Opportunity # 3 - Isolate Nonoperating Boilers For Shutdowns Greater Than Two Months to Reduce Excess Air

Test measurements of the economizers show very high levels of excess air due to nonoperating boilers. Isolation of nonoperating boilers that will be out of service greater than two months will reduce some of the unwanted air leakage. The estimated energy savings from isolating nonoperating boilers is 15.6 billion Btu (16,500 GJ) annually. This provides $28,300 savings based upon local prices and $33,200 savings based upon world wide prices. The estimated cost of the project is $2,700. The calculations show a rapid payback for this project: 34 days based on local prices and 30 days based on worldwide prices. Due to the rapid payout of approximately 1 month, this energy conservation opportunity should be implemented as soon as possible.

See Appendix "A" for relevant calculations and supporting data.

4.0 SYSTEMS AUDITED - SHORT TERM RECOMMENDATIONS

4.1 Boilers (continued)

Energy Conservation Opportunity #4 -Repair Insulation on Boiler Feed Water Lines

Measurements and calculations show an annual heat loss of 546 million Btu (576 GJ) for 7 meters of uninsulated 150 mm diameter boiler feedwater line. Insulation of the line will save $ 990 based upon local prices and $ 1,162 based upon worldwide prices at a total cost of $ 427. The calculations show a rapid payback for this project: 2.75 months based on local prices and 2.3 months based on worldwide prices. Due to the rapid payout, this energy conservation opportunity should be implemented as soon as possible.

See Appendix "A" for relevant calculations and supporting data.

4.2 Water Heaters

KOMMUNAR/ZAZ has three water heaters able to supply 627 GJ/hr of heat to the water. Each of two identical heaters are able to supply 209 GJ/hr of heat to the water, one heater is able to supply 419 GJ/hr of heat to the water. The water heaters are only used in the winter. At present, the winter heating load is 481 GJ/hr. The water heaters supply energy to heat the plant and nearby houses outside of the plant. Although the heaters have no air preheaters, they have high efficiency — about 87% according plant personnel. Since the weather was warm, only one water heater was operating at reduced load at the time of the audit. The measured efficiency was 99% at this reduced load. Because of the situation and the high thermal efficiency of the heaters, the audit team was unable to identify any energy conservation opportunities for the water heaters. Water heater characteristics are presented in Table 3.

4.0 SYSTEMS AUDITED - SHORT TERM RECOMMENDATIONS

4.2 Water Heaters

Table 3
Water Heater Characteristics

Water Heater	Date	Heat Input	Water Outlet Temperature		Design Pressure	Combustion Air Temperature
		(Gcal/hr)	Design (°C)	Operating (°C)	(bar)	
8	1967	50	150	70	8	Ambient
9	1985	50	150	NA	8	Ambient
10	1987	100	170	NA	8	Ambient

4.3 Steam System

The steam boilers described above provide steam to many different users of varying sizes throughout the complex. In the boilerhouse the steam is nominally let down from 8 bar to 2.5 bar. Thus it is available at most users at a pressure of 2.5 bar less any pressure drop between the boilerhouse control valve and the individual user.

The two main steam lines that transport steam from the boilerhouse are 300 mm in diameter on the right side of the plot and 700 mm in diameter on the left side of the plot. Steam is transported underground in most locations.

In observing the lines comprising the steam system, almost no steam leaks were seen. However, one large leak was observed in the main building in which steam was leaking from a large valve. This should be fixed as soon as possible.

4.3 Steam System (continued)

Of the nominal 50 metric tons per hour of steam that is produced by the operating boilers, the largest users are the following:

Name of Shop	Steam Consumption Metric Tons/Hour
Metal Coatings	9.0
Painting	6.0
Mechanical	3.0

The steam flow to the various users, both large and small is not under a proper system of flow control. To improve efficiency in steam usage, we recommend the installation of automatic flow control valves on all large users of steam.

Many of the steam traps in the plant do not work. They are mostly thermodynamic steam traps that do not work well at low pressure. A different type of trap is needed to replace these. New steam traps are also needed for those services in which steam traps are currently not being used at all.

Energy Conservation Opportunity #5 - Fix Rather Large Leak from Steam Valve in Main Building

The plant should fix this leak, as soon as possible. It is estimated that approximately 50 Kg/hr of steam is currently being lost. This corresponds to an annual loss of $ 630, based on local prices and $ 1,830, based on worldwide prices. For the former the simple payback would be approximately 1.9 months and for the later 20 days. The cost to repair should be no more than $ 100. In terms of energy, approximately 0.42 billion Btu (440 GJ) per year could be saved by fixing this leak.

See Appendix "A" for relevant calculations.

4.3 Steam System (continued)

Energy Conservation Opportunity #6 - Install Automatic Flow Controllers on Large Users of Steam

The use of automatic flow controller on the large users of steam will greatly aid in directing the steam to its users in the proper quantities needed for efficient operation. It is estimated that 7,500 metric tons of steam is currently lost each year, due to inefficient utilization and distribution. This corresponds to $ 22,800, based upon local prices and $ 66,200, based upon worldwide prices. In terms of energy 15.3 billion Btu (16,100 GJ) is currently lost annually.

The estimated project cost to install the valves is $ 93,300. The simple payback, based upon local energy prices would be 4 years and based upon worldwide energy prices would be 1.4 years.

See Appendix "A" for relevant calculations.

4.4 Condensate System

Because many of the existing steam traps do not work properly and because many steam services do not have any steam traps, the amount of condensate that can presently be collected and recycled back to the boilers is relatively small. At present, condensate is recovered from the paint preparation shop and the mechanical assembly workshop and is pumped to a collector and then to the boilers.

The tool shop and the mechanical equipment repair shop each supply non-pumped low pressure condensate. The collector to which this condensate is sent is without a cover and a large quantity of steam may be seen being vented from this collector. A suitable cover is needed to prevent this loss of energy.

At present, the plant estimates that only 30 percent of the condensate produced is currently being recovered. The remainder is going hot to the sewer. They have had some plans to recover more condensate, but have not been able to implement them, due to a shortage of money.

4.4 Condensate System (continued)

Due to the low recovery of condensate, additional make-up water must be used. Associated with this are three additional expenses:

- The cost of the make-up water
- The cost of treating the make-up water
- The cost of heating the make-up water

Increasing the amount of condensate recovered is certainly a critical item in improving the efficiency of the entire system.

Energy Conservation Opportunity #7 - Minimize Vent Losses on Opened Condensate Collection System

It is important that the plant install a cover on the collector, as soon as possible. It is estimated the plant currently losses 10,400 metric tons per year of steam through the uncovered opening in the collector. This corresponds to $ 6,300 based on local prices and $ 18,400 local based on worldwide prices. In term of energy 4.2 billion Btu (4,400 GJ) is lost annually.

The estimated project cost to install the cover and cage on the collector is $ 500. The simple payback, based upon local energy prices would be 29 days and based upon worldwide energy prices would be 10 days.

See Appendix "A" for relevant calculation.

4.5 Compressed Air System

The compressed air system consists of four (4) separate stations. Station No. 1 has four (4) piston compressors, 600 KW each. One hundred cubic meters per minute of air can be compressed by each compressor. Normally, two (2) compressors are in operation and the other two are on standby. These compressors have been in service since 1956.

Station No. 2 consists of five (5) piston compressors, 300 KW each. Fifty cubic meters per minute of air can be compressed by each compressor. Normally, two (2) compressors are in operation and the other three are on standby. These compressors have also been in service since 1956.

4.5 Compressed Air System (continued)

Station No. 3 contains the largest compressors. There are four (4) turbo compressors, 1500 KW each. Each compressor can compress 250 cubic meters per minute of air. Normally three (3) compressors are in operation and one is on standby. These compressors have been in service since 1970.

Station No. 4 consists of three (3) piston compressors, 625 KW each. Each compressor can compress 120 cubic meters per minute of air. Normally, two (2) compressors are in operation and one is on standby. The compressors have been in service since 1989.

The largest users of air in the plant are for the pressing of metal, for painting and for welding. Stations 1, 2 and 3 operate at 5.6 bar and Station 4 at 6.5 bar. Station 4 is dedicated to painting and the assembly building only.

The entire system of compressors normally compresses 1,390 to 1,500 cubic meters per minute of air. This is distributed by manual control to the various users without the benefit of automatic flow controllers. We recommend that automatic flow controllers be installed on all the large users of compressed air to help conserve energy by more efficiently distributing the air to where it is needed.

Energy Conservation Opportunity #8 - Install Automatic Flow Controllers on Large Users of Compressed Air

The use of automatic flow controllers on the large users of compressed air will greatly aid in directing the compressed air to its users in the proper quantities needed for efficient operation. It is estimated that 3.1 million kWh per year is lost in the inefficient utilization and distribution of the compressed air. This corresponds to $ 48,100, based upon local prices and $ 155,000, based upon worldwide prices.

The estimated project cost to install the valves is $ 72,100. The simple payback, based upon local energy prices would be 1.5 years and based upon worldwide energy prices would be 6 months.

See Appendix "A" for relevant calculations.

4.0 SYSTEMS AUDITED - SHORT TERM RECOMMENDATIONS

4.6 Electrical System

There are nine (9) sources of electricity coming into the plant. During normal operation the electrical demand is 50 MW. In 1994, the electrical consumption for the entire year was 203 million kWh. The electrical system for the entire plant can best be seen on the one line electrical diagram of the plant which was last updated on June 6, 1993.

The largest single consumers of electricity in the plant are the four (4), 1,500 KW each, air compressors and the 2,000 KW conveyors. For the large air compressors the use of variable speed motors may be an effective way of improving efficiency and reducing the consumption of electricity.

These are periods of time, when items of equipment are left running, thus consuming electricity, even though they are not in use. Procedures must be put in place to prevent this from happening.

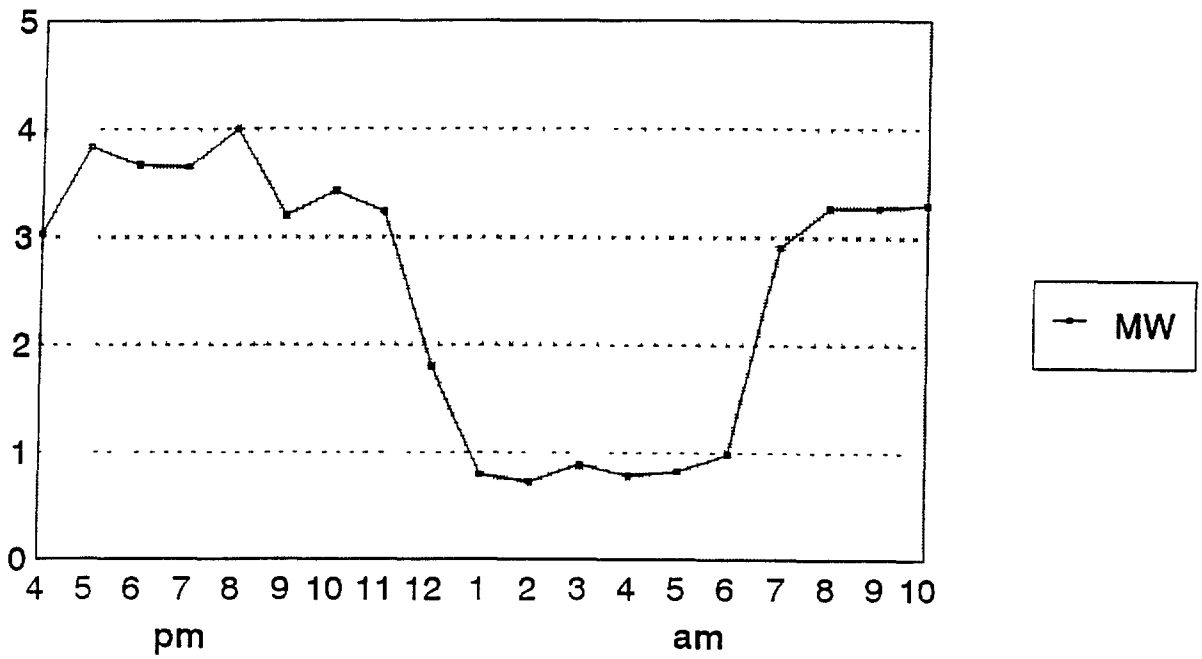
In most areas of the plant the use of electricity for lighting is definitely not excessive. The one area where perhaps a savings in the use of electricity for lighting may be possible is in the automobile final assembly building. In this building it appears that certain locations are too well lit and other are too dark. It would appear that some improvement to this lighting is possible.

Energy Conservation Opportunity #9 - Shutdown Equipment That Does Not Always Need To Run

If a comprehensive survey could be carried out by plant personnel, using the Dranetz 808A Power Analyzer, to pinpoint exactly which items of equipment are running, when they need not be in operation, a good deal of electrical energy could be saved. Data taken during the evening of March 9 and 10, 1995 using a Dranetz 808A Power Analyzer shows that the power consumption for a portion of the plant which included half the Compressor Station Number 4, half of the Paint Shop and half of the Welding Shop dimished only from about 3.2 MW to 0.8 MW during the late night period. This indicates that certain items of equipment, which were still consuming approximately 25% of the normal electrical consumption, were still running during this period. See figure on next page.

KOMMUNAR/ZAZ CAR PLANT

MARCH 9 AND 10 1995



MW VS. TIME FOR PORTION OF PLANT

4.6 Electrical System (continued)

It is estimated that 26,000 MHh is currently lost each year, due to items of equipment running, when they should not be in operation. This corresponds to $ 403,000, based on local prices and $ 1,300,000, based on worldwide prices.

The estimated project cost to obtain a Dranetz 808A Power Analyzer and carry out the survey is $ 14,100. The simple payback, based upon local prices would be 13 days and based upon worldwide energy prices would be 4 days.

We recommend that USAID purchase the Dranetz 808A Power Analyzer on behalf of the plant, to assist in the implementation of this ECO.

See Appendix "A" for relevant calculations.

Energy Conservation Opportunity #10 - Reduce Excess Lighting and Improve Dimly Lit Areas in Certain Parts of Automobile Final Assembly Building

This ECO was investigated in terms of the installation of high pressure sodium fixtures in the automobile final assembly building. The annual savings in energy would be 20,000 KW for an expenditure estimated to be $ 25,000. Based upon local prices the payback would be a highly unattractive 81 years and based upon worldwide prices it would be an equally unattractive 25 years. This ECO should not be pursued.

See Appendix "A" for relevant calculations.

4.7 Energy Management and Training

In addition to the various areas of the plant that were audited in order to discover energy conservation opportunities, emphasize was also placed on learning about the energy management and training procedures used in the plant, in order to see if energy conservation opportunities could be discovered in these areas, as well.

What was found may be briefly summarized as follows:

- The plant does not have a single individual who is responsible for energy conservation, but does have a committee known as the "Bureau for Energy Usage."

4.6 Energy Management (continued)

What was found may be briefly summarized as follows:

- The plant has a single individual who is responsible for energy conservation, but does not have a fully functioning energy conservation committee.

- The plant does not have a yearly budget which is set aside for energy conservation projects.

- The plant must make recommendations to a Technical Council to receive approval for an energy conservation project. Even if approval is obtained from the Technical Council, the council cannot insure that founds will be provided for the project.

- The plant has no criteria, such as payback or discounted cash flow, for making investments in the plant to conserve energy. Their only criteria for making energy conservation investments is based upon energy usage per quantity of product.

- Basic maintenance, such as the repair of steam leaks and the repair or replacement of faulty insulation, needs to be greatly improved.

Based upon the above findings, we would like to recommend improvements in energy management procedures for the plant.

Energy Conservation Opportunity #9 - Institute Improved Energy Management Procedures

The establishment of improved Energy Management Procedures is vital in carrying out a proper energy conservation program. A fully functional energy conservation committee must be put in place under the direction of the single individual who is currently responsible for energy conservation. The committee will be responsible to develop an appropriate agenda and proper planning for energy conversation implementation. The highest proprietary must be given to the establishment of a yearly budget for energy conservation. A criteria such as a 3 year payback or 15% discounted cash flow should be used for making decisions as to whether or not to invest in an energy conservation project. High priority must be given to improving basic maintenance.

4.6 Energy Management (continued)

In addition the Energy Conservation Committee must 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;
ADVERTIZE successful energy conservation projects and lessons learned; and
REPLICATE successful conservation projects to all parts of the plant.

It is estimated that a 10% improvement in efficiency could be achieved. This is based upon our experience over the past fifteen (15) years in similar industries in Egypt, South America and the Far East. Based upon local prices the overall yearly savings would be $56,200. For worldwide prices this would be approximately $200,000. The annual savings would be 0.17 trillion Btu (179,400 GJ).

The cost of the program would be negligible and the payout would be immediate.

See Appendix "A" for relevant calculations.

4.7 Energy Management and Training (continued)

Energy Conservation Opportunity #12 - Institute Energy Conservation Training of Plant Personnel

It is highly recommended that an Energy Conservation Training Program be instituted for plant personnel. It is estimated that a 5% savings would be obtained though the training program. The yearly savings, based upon local prices, would be $ 359,000. For worldwide price this would be approximately $ 1,000,000. The annual savings would be 0.19 trillion Btu (200,500 GJ).

The cost of the program would be negligible and the payout immediate.

See Appendix "A" for relevant calculations.

5.0 SYSTEMS AUDITED - LONG TERM RECOMMENDATIONS

5.1 Electrical System

A description of the electrical system has already been given above in Section 4.6. This will not be repeated here, except to point out that two of the electrical system related energy conservation opportunities are long term ones which will involve an investment in order for implementation to be achieved. These opportunities are described below:

Energy Conservation Opportunity #13 - Improve Low Power Factor Caused by Induction Motors During Robotics Welding

To improve the power factor of the robotic welding machines would require approximately 2,000 KVAC of correction. The estimated project cost is $ 75,000. Based on local costs the payback would be 4.8 years and based on worldwide cost 1.5 years. This ECO is only moderately attractive.

See Appendix "A" for relevant calculations.

Energy Conservation Opportunity #14 - Install Variable Speed Drive on One or More Turbo Air Compressor Motors

The installation of variable speed drives and new motors on the four air compressors would cost approximately $ 1,000,000. The annual energy savings would be 3.4 million KW. Based upon local prices this corresponds to payback of 19.1 years and based upon worldwide prices a payback of 5.9 years. These paybacks are not attractive and this ECO should be pursued.

See Appendix "A" for relevant calculations.

5.2 Steam System

A description of the steam system has already been given above in Section 4.3. This will not be repeated here, except to point out that one of the recommended steam-related energy conservation opportunities is a long term one which will involve an investment in order for implementation to be achieved. This opportunity is described below:

5.0 SYSTEMS AUDITED - LONG TERM RECOMMENDATIONS

5.2 Steam System (continued)

Energy Conservation #15 - Add or Replace Non-Operating Steam Traps

It is recommended that the plant acquire approximately 150 new Inverted Bucket type steam traps. This will cover both the steam traps that currently do not work and the services that currently do not have steam traps, but do require them. It is conservatively estimated that the new installation of 150 steam traps will properly condense and recover 20% of the current steam load or 10 metric tons/hr. On an annual basis this would be 41,600 metric tons. This corresponds to $ 126,500, based upon local prices and $ 166,400, based upon worldwide prices. The energy savings would be 84.9 billion Btu (89,600 GJ) per year.

The estimated project cost to purchase and install 150 new Inverted Bucket type steam traps is $ 107,600. The simple payback, based upon local prices would be 10.2 months and based upon worldwide prices would be 7.8 months.

See Appendix "A" for relevant calculations.

5.3 Condensate System

A description of the condensate system has already been given above in Section 4.4. This will not be repeated here, except to point out that one of the recommended condensate-related energy conservation opportunities is a long term one which will involve an investment in order for implementation to be achieved. This opportunity is described below:

Energy Conservation Opportunity #16 - Collect Additional Condensate and Recycle to Boilerhouse

To implement this ECO it is necessary that new equipment be installed, consisting of a condensate collection drum, a condensate pump and spare and a vent condenser to recover approximately 25 metric tons per hour of additional condensate. This will improve the total condensate recovery of the entire plant for 30% to 80%. On an annual basis an additional 104,000 metric tons would be recovered. This corresponds to $ 31,200, based upon local prices and $ 91,700, based upon worldwide prices. The yearly energy savings would be 21.2 billion Btu (22,400 GJ).

5.0 SYSTEMS AUDITED - LONG TERM RECOMMENDATIONS

5.3 Condensate System (continued)

The estimated project cost would be $ 206,000. The simple payback, based upon local prices would be 6.6 years and based upon worldwide prices would be 2.2 years. Based on current economics this ECO should not be pursued.

See Appendix "A" for relevant calculations.

6.0 TRAINING ACCOMPLISHED

An objective of this project was to transfer as much information and hands on training of energy auditing techniques to local technical personnel so that they may continue this same work after the foreign consultants have completed their brief visit.

Energy management personnel, boilerhouse engineers, technicians, and operators, and plant electrical engineers 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;
- conducting the audit to identify potential conservation measures;
- hands on utilization of audit equipment to quantify potential energy savings;
- discussion on proper excess air control in fired equipment to avoid carbon monoxide formation;
- discussions of typical energy management practices is the US; and
- final "report out" meeting with plant Chief Engineer and Shop Managers.

7.0 IMPACT OF SAVINGS

The recommended Energy Conservation Opportunities (ECO's) and their potential savings represent a meaningful percentage of the total energy usage of the plant. The demonstration of technologies such as automatic combustion controls can lay the groundwork for additional savings from similar projects that can provide substantial reductions in the plant's energy use. In addition the ECO's recommended are not specific to car production. They are primarily related to control of energy consumption within a plant and will be applicable to many Ukrainian production facilities.

8 0 RESULTS OF FOLLOW UP VISIT

8 1 Visit Objectives

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

- Assess energy conservation achievements in each plant in response to the 1995 audit
- Assist the plants with the use of the newly arrived measuring instruments
- Identify and report problems for correction with any of the instruments
- Discuss equipment installation

8 2 Main Energy Conservation Opportunities (ECOs) during 1995

The chief ECOs identified during the 1995 audit were as follows

ECO #	Description	Estimated Savings (GJ)
01	Purchase Portable Boiler Efficiency Measurement Device	107,700
02	Install Automatic Combustion Controls, Adjust Burners and Clean Heat Transfer Surfaces	85,000
11	Institute Improved Energy Management Procedures	400,900
12	Institute Energy Conservation Training of Plant Personnel	200,500
15	Add or Replace Non-operating Steam Traps	89,600
09	Shut Down Equipment That Does Not Always Need to Run	26,000 MWh

An Enerac 2000 combustion analyzer was purchased to address ECO #1 An automatic boiler control consisting of a lead/lag air/fuel ratio control with oxygen trim was purchased to address ECO #2 A Rustrak Power Logger RR-1233A-2-0-0 was purchased to help the plant reduce electricity use, ECO #9

8 3 Status of Plant during July, 1997 Visit

Dr James P Stumbar visited Kommunar/ZAZ on July 12 and July 13 and met with Mr Konstantin Markovich Krakmal, Chief Power Manager, Mr Valentin Fedorovich Diadechko, Deputy Chief Power Manager; and Mr Victor Fedorovich Kozhanov, Boiler Chief The manufacturing operations at the plant had been severely reduced by lack of customers At the time of the visit, the plant was not operating

Kommunar/ZAZ had taken steps to reduce energy use by turning off lighting and unused electrical equipment They had also instituted a program to reduce electricity costs by avoiding operations during hours of peak electrical demand Equipment ordered for the plant were still under customs control.

Kommunar/ZAZ has been negotiating with Daewoo Auto Company of Korea and GM Corporation of the United States At the time of this report, Parliament has written off 66,000,000 Hryvnia of the plant's debt and there are a few remaining items to finish the negotiations The company anticipates resuming larger scale manufacturing of automobiles during November/December 1997.

8 4 Accomplishments during Visit

The results of the follow up visit to Kommunar/ZAZ auto plant are as follows

- Since the Enerac 2000 combustion analyzer and the Rustrak Ranger electrical analyzer were still in customs, the audit team arranged a visit to Zaporozkok Coke plant by the Deputy Chief Power Manager, the Boiler Chief, and an instrument laboratory technician of the auto plant to demonstrate the instrument The interaction between the engineers and technicians from the two plants were excellent The meeting provided the coke plant an opportunity to proudly share their experience with the combustion analyzer and allowed the audit team to demonstrate the setup of the electrical analyzer for both plants As a result of the visit, contacts were made and telephone numbers were exchanged so that the two plants could consult with each other on the use of the instruments

- The automatic boiler control system was at the plant but it was under control of customs Installation of the control system was discussed with Dr James Stumbar The plant has decided to install the control system on Boiler 1 after putting it back into service The plant will use one of the forced draft fans to supply combustion air and install the combustion air duct with its air flow meter and control damper as a completely independent unit The discussion showed that the fan was adequate to supply the required combustion air to this boiler. The fuel spool piece will be located adjacent to the right hand side of the boiler when looking at the front face of the boiler The integration

of the fuel spool piece with the present flame safeguard system was discussed. The need to connect the two block (automatic shutoff) valves to the flame safeguard system to ensure rapid closure was emphasized during the discussions This connection must be made in the emergency trip circuit since these valves are protected against electrical interruption by a continuous power supply The location for the oxygen trim analyzer was also discussed. The analyzer should be installed before the economizer

- The operating principles of the control system were also discussed The plant was informed that the control system was a lead/lag system When firing rate must be increased the air flow is increased followed by an increase in the fuel flow Air flow leads fuel flow, fuel flow lags air flow When the firing rate must decrease, the fuel flow is decreased followed by a decrease in the air flow. Fuel flow leads air flow; air flow lags fuel flow

  A master controller receives a demand signal from the measured steam header pressure If the header pressure drops, the controller will increase the firing rate in the boiler automatically according to the following sequence The controller sends a signal to increase the opening of the air damper As the air damper opens, the air flow meter sends a signal to the fuel controller which begins to open the fuel valve to maintain the proper air to fuel ratio Fuel flow is measured and a signal is sent to the fuel controller Air and fuel flow rates are compared When the flows are in the proper ratio the fuel controller maintains the fuel valve at a constant position. The oxygen trim analyzer compares the measured oxygen to the setpoint If the oxygen is different than the setpoint, the analyzer controller sends a signal to the air controller to trim (make a small adjustment) the air damper

  The attached photographs show training sessions at Zaporozkok plant, instrument usage in the plants and automatic control equipment for the boiler staged for installation

8 5 Work Needed to Complete Implementation

As discussed below, the plant was most concerned about the installation and Ukranian certification of the control system The work needed to complete implementation of the energy conservation measures are as follows

- Complete customs clearance of instruments and installation of boiler control sustem, including operational certification by Ukrainian authorities

- Obtain adapters for connection of intermediate current transformers (0 to 1000 amps) The plant needs male to female adapters

8 6 Lessons Learned

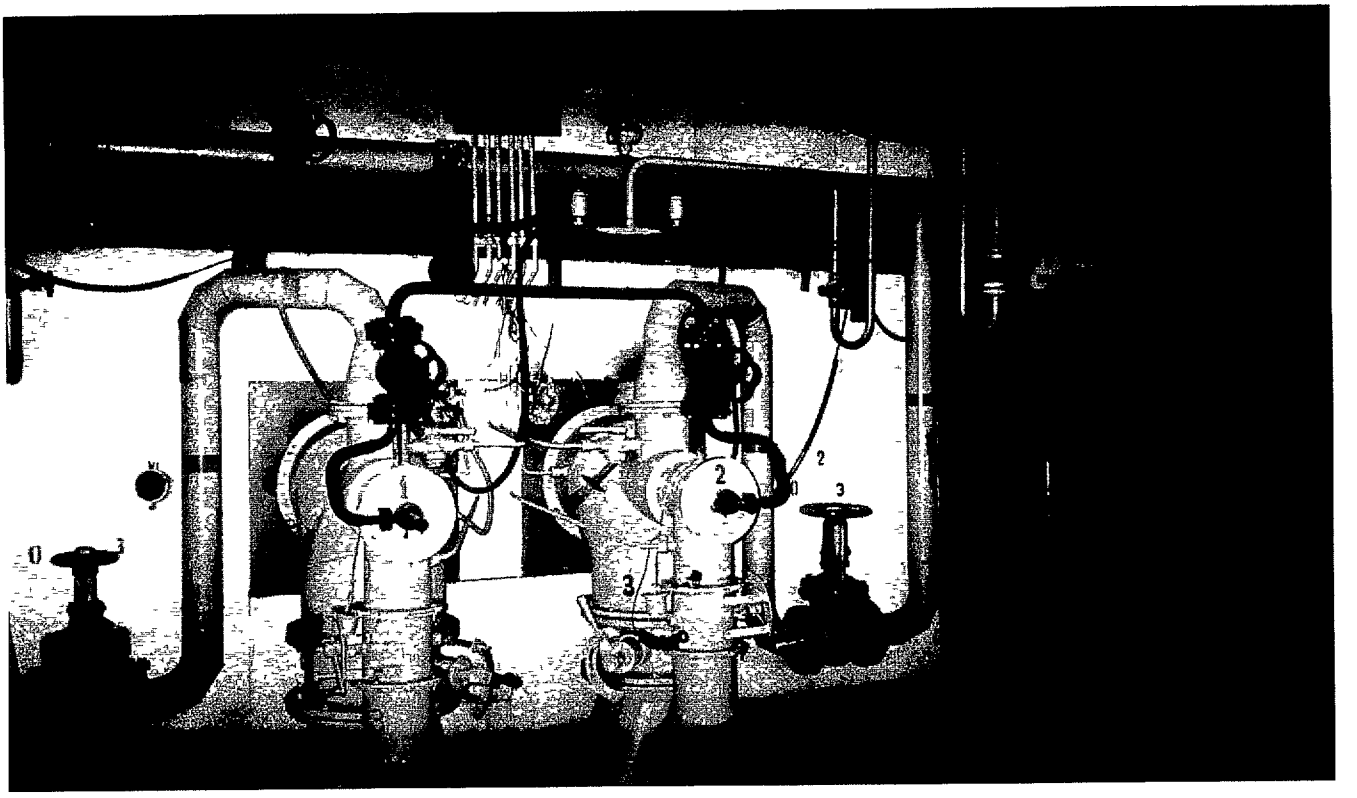
The effectiveness of future programs can be improved by addressing the following items discovered during the visits

Future projects should consider purchase of Personal Computers (PCs) with Russian software A PC with an integrated software package such as Microsoft Office or Lotus Smart Suite would be a useful tool for tracking energy management in the plants Applications would include steam trap leak detection and repair, steam system leak detection and repair; and tracking of wasted electricity in various parts of the plant

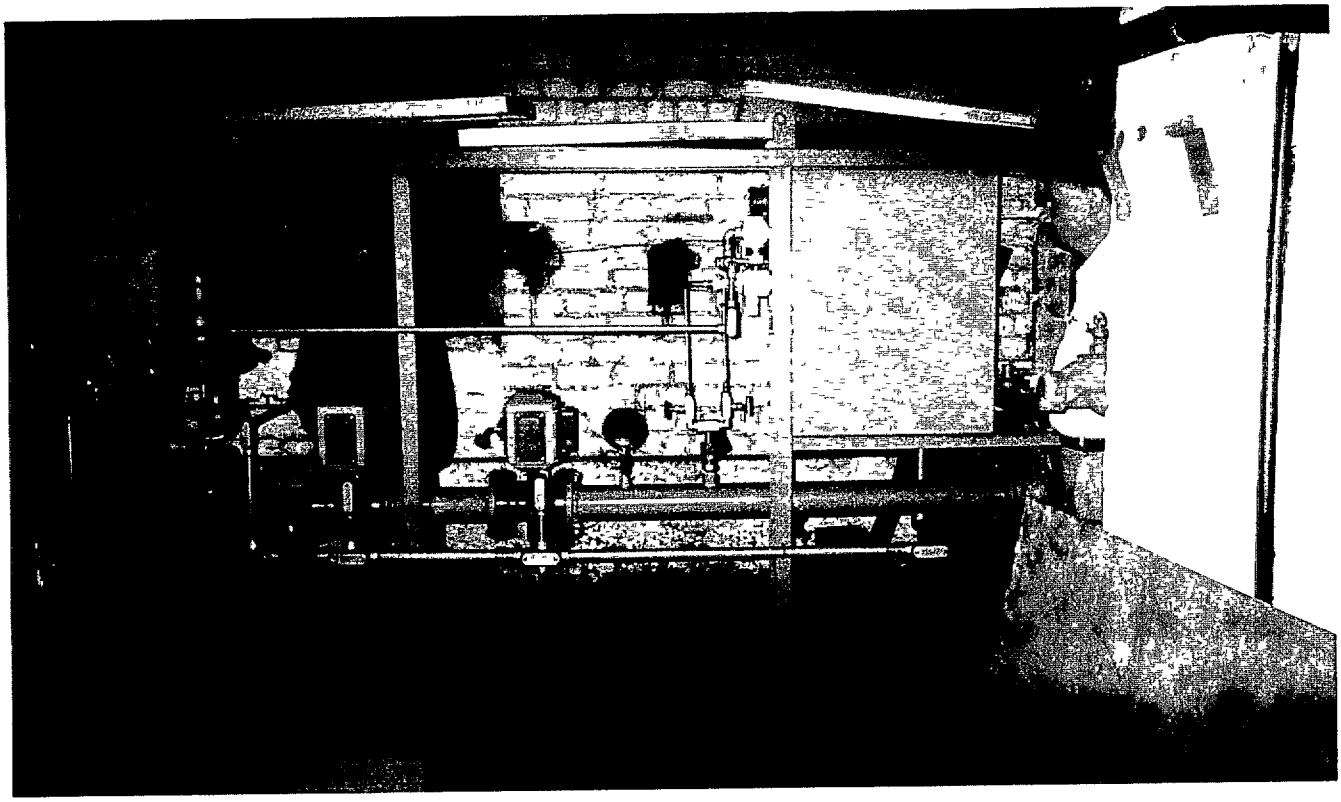
Purchased instruments should be checked for completeness and correctness of parts and for ability to operate as specified prior to shipment to the plants

Issues of local certification of equipment should be addressed to ensure that the equipment can be used effectively.

Equipment for proper calibration of supplied instruments should be provided to ensure long term usefulness of the instruments

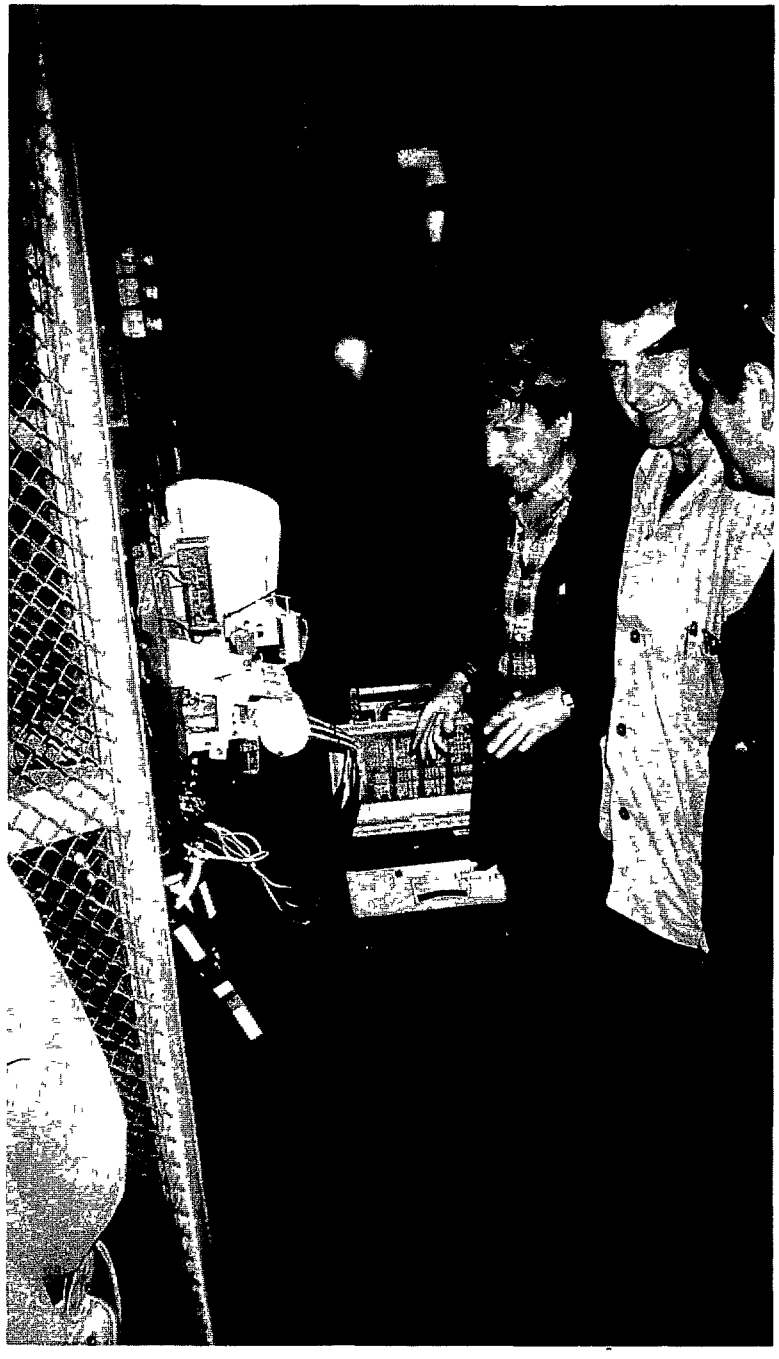


Burners at Kommunar AutoZAZ Showing Manual Control Value



Automatic Boiler Control System Showing Fuel Spool Piece & Control Panel
at Kommunar AutoZAZ

Emergency Fuel Sutoff Valve at Kommunar AutoZAZ



Zaporozkok - Rustrak Ranger Energy Analyzer Hooked Up to Show Kommunar AutoZAZ and Zaporozkok Use of Instrument

APPENDIX "A"

Energy Conservation Opportunities (ECO's), Savings Calculations, Implementation Costs, Specifications

ENERGY CONSERVATION OPPORTUNITY CALCULATION SECTION CONTENTS

ECO-01	Purchase Portable Boiler Efficiency Measurement Device
ECO-02	Install Automatic Combustion Controls, Adjust Burners, and Clean Heat Transfer Surfaces
ECO-03	Isolate Nonoperating Boilers for Shutdown Greater Than Two Months to Reduce Excess Air
ECO-04	Repair Insulation on Boiler Feed Water Lines
ECO-05	Fix Rather Large Leak from Steam Valve in Main Building
ECO-06	Install Automatic Flow Controllers on Large Users of Steam
ECO-07	Minimize Vent Losses on Opened Condensate Collection System
ECO-08	Install Automatic Flow Controllers on Large Users of Compressed Air
ECO-09	Shutdown Equipment That Does Not Always Need To Run
ECO-10	Reduce Excess Lighting and Improve Dimly Lit Areas in Certain Parts of Automobile Final Assembly Building
ECO-11	Institute Improved Energy Management Procedures
ECO-12	Institute Energy Conservation Training of Plant Personnel
ECO-13	Improve Low Power Factor Caused By Induction Motors During Robotics Welding
ECO-14	Install Variable Speed Drive on One or More Turbo Compressor Motors
ECO-15	Add or Replace Non-Operating Steam Traps
ECO-16	Collect Additional Condensate and Recycle to Boilerhouse

ECO-01

Purchase Portable Boiler Efficiency Measurement Device

DESCRIPTION OF EXISTING EQUIPMENT AND OPERATING CONDITIONS

Analyses of stack gases with a portable analyzer showed that the boilers had high carbon monoxide emissions and high excess air.

DESCRIPTION OF PROPOSED MODIFICATIONS

Better control of excess air is needed promptly to conserve energy. The quantity of energy that is currently being lost is estimated in the calculations given below.

ENERGY SAVINGS CALCULATION

Based on the measurements the boilers averaged 66% efficiency at the economizer outlet. After trimming the boilers averaged 83.0% efficiency at the economizer outlet. A 9% efficiency improvement is forecast for this measure. The plant should be able to operate consistly with 75% or better efficiency. See tables "A-1" through "A-3", following ECO-02.

Average Steam flow:	28.8 metric ton/hr
Enthalpy added to steam:	
1195.5 Btu/lb saturated x 1.055 kJ/Btu x 2.205 kg/lb	= 2781 kJ/kg
182.0 Btu/lb saturated liquid at 100 °C x 1.055 x 2.205	= 423 kJ/kg
	= 2358 kJ/kg
Total heat input to steam:	
2358 kJ/kg x 28.8 T/h (average steam load) x 1000 kg/T	= 67,900,000 kJ/hr
	= 67.9GJ/hr
Heat input to boiler:	
67.9 GJ/hr/0.66 (efficiency) before implementation	= 102.8 GJ/hr
67.9 GJ/hr/0.75 (efficiency) after implementation	= 90.5 GJ/hr
Total estimated savings	= 12.3 GJ/hr
8760 hrs of operation 8760*12.3	= 107,700 GJ saved per year
	= 102.1 billion Btu per year
107700x1,000,000/36652	= 2,940,000 m^3/yr saved

ECO-01 (continued)

2,940,000 x \$63 US/1000 m^3	Ukrainian Price	= \$185,200 USD/yr
2,940,000 x \$74 US/1000 m^3	World Price	= \$217,600 USD/yr

Project to purchase Portable Analyzer

Cost of Recommended Bacarach Model CA 300NSX
Combustion Analyzer = \$7,000 USD

Simple Payback = Cost = 7,000 x 365 = 14 days
Local Energy Prices Savings 185,200

Simple Payback = Cost = 7,000 x 365 = 12 days
Worldwide Energy Prices Savings 217,600

B \ECO01 CP

ECO-02

Install Automatic Combustion Controls, Adjust Burners, and Clean Heat Transfer Surfaces

DESCRIPTION OF EXISTING EQUIPMENT AND OPERATING CONDITIONS

Analyses of stack gases with a portable analyzer showed that the boilers had high carbon monoxide emissions and high excess air.

DESCRIPTION OF PROPOSED MODIFICATIONS

Better control of excess air is needed promptly to conserve energy. The quantity of energy that is currently being lost is estimated in the calculations given below.

ENERGY SAVINGS CALCULATION

Based on the measurements the boilers averaged 66% efficiency at the economizer outlet. After trimming the boilers averaged 83.0% efficiency at the economizer outlet. A 9% efficiency improvement is forecast for this measure. When the both ECO-1 and ECO-2 are combined, the plant should be able to operate consistly with 84% or better efficiency. See tables "A-1" through "A-3", following this ECO.

Average Steam flow:	28.8 metric ton/hr
Enthalpy added to steam:	
1195.5 Btu/lb saturated x 1.055 kJ/Btu x 2.205 kg/lb	= 2781 kJ/kg
182.0 Btu/lb saturated liquid at 100 °C x 1.055 x 2.205	= 423 kJ/kg
	= 2358 kJ/kg
Total heat input to steam:	
2358 kJ/kg x 28.8 T/h x 1000 kg/T	= 67,900,000 kJ/hr
	= 67.9 GJ/hr
Heat input to boiler:	
67.9 GJ/hr/0.75 (efficiency) before implementation	= 90.5 GJ/hr
67.9 GJ/hr/0.84 (efficiency) after implementation	= 80.8 GJ/hr
Total estimated savings	= 9.7 GJ/hr
8760 hours * 9.7 Gj/hr	= 85,000 GJ saved per year
	= 81.0 Billion Btu per year

ECO-02 (continued)

85,000x1,000,000/36652		= 2,319,000 m^3/yr saved
2,319,000 x \$63 US/1000 m^3	Ukrainian Price	= \$ 146,100 USD/yr
2,319,000 x \$74 US/1000 m^3	World Price	= \$ 171,600 USD/yr

Project to purchase automatic boiler controls for boiler 2

Fuel Gas Control Valve with operator
Fuel Gas Flow meter with transmitter
Multileaf air damper
Air Flow meter (Annubar with transmitter)
Programmable Controller
Solid State (Zirconium Oxide) Oxygen Meter
Air Ducting
Fuel Piping

Estimated Project Cost (for equipment to be paid for by USAID)
Total \$ 78,600

Simple Payback = Cost / Savings = 78,600 / 146,100 x 12 = 6.5 months
Local Energy Prices

Simple Payback = Cost / Savings = 78,600 / 171,600 x 12 = 5.5 months
Worldwide Energy Prices

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TABLE "A–1"
KOMMUNAR/ZAZ CAR PLANT
ZAPOROZHIA, UKRAINE
BOILER STACK MEASUREMENTS

Boiler #	Time	Stack Temp Deg C	Excess O2 vol %	Carbon Dioxide vol %	Excess Air %	Efficiency (Sensible) %	Carbon Monoxide vppm	Nitrogen Oxides vppm	Comments
02–Mar–95									
4	14 15	382	4 4	9 2	24	82 4	6	62	
3	15 34	338	1 4	10 9	6	87 2	3222	43	High CO
3	15 51	364	3 5	9 7	18	84 8	6	81	Burners Need Adjustment
5	16 00	370	6 0	8 3	36	82 4	2176	34	High CO, Burners Need Adjustment
2	16 26	322	8 1	7 2	57	83 0	0	52	High Excess Air
03–Mar–95									
8	10:11	85	4 7	9 1	26	96 7	1	90	Water Heater at Low Load
2	10 25	329	8 2	7 1	59	81 1	5	56	
2	10:39	308	6 2	8 2	38	84 8	4	72	
2	10 53	288	3 1	10 0	15	88 1	3075	55	High CO
2	11 08	293	4 0	9 5	21	87 4	0	83	Low Excess Air Limit
09–Mar–95									
5	10 57	308	6 4	8 1	40	85 0	0	90	
5	11 04	294	6 3	8.2	39	85.9	49	72	Low Excess Air Limit
3	11:18	331	1 1	11 1	4	87 5	3238	35	High CO
3	11:36	371	2 7	10 3	13	84 8	22	83	Low Excess Air Limit
4	11:53	379	1 6	10 8	7	85 3	3204	25	High CO
4	12 26	409	3 7	9 6	19	82 5	0	66	
2	12 35	297	1 9	10 6	8	88 8	2182	46	High CO
2	14 23	312	3 1	10 0	15	87 1	0	84	Low Excess Air Limit
Economizer 02–Mar–95									
2	15.15	219	11 8	5 1	118	85 0	210	38	High CO, High Excess Air
1	16 58	234	10 5	5 8	92	86 0	1398	41	High CO, High Excess Air
09–Mar–95									
1	10 03	215	9 1	6.6	69	87.7	3274	24	
2	10 36	192	12 9	4 5	146	85 3	1994	26	
1	14.38	223	10 0	6 1	83	86 9	12	47	After Boiler Adjustment
2	14 46	207	12 1	4 9	125	85 6	258	19	After Boiler Adjustment

Note Recorded efficiencies include only losses from sensible heat in flue gases Losses from unburned carbon monoxide, (> 18% at 3200 vppm), wall losses and blowdown losses (about 3%) are not included

BOILER PLANT EFFICIENCY RESULTS

Economizer 09–Mar–95	Time	Flue Gas Loss		Unburned CO Loss	Wall/Blowdown Loss	Total Loss	Net Efficiency
1	10 03	12.3%		18 2%	3 0%	33 5%	66 5%
2	10 36	14 7%		15 9%	3 0%	33 6%	66 4%
1	14.38	13 1%		0 1%	3 0%	16 2%	83 8%
2	14:46	14 4%		1 9%	3 0%	19 3%	80 7%

Flue Gas Loss = 100 – Sensible Heat Efficiency (stack measurement above)
Unburned CO Loss = (See Table "A–3")
Wall/Blowdown Loss = Estimated (per standard practice)

TABLE "A-2"
KOMMUNAR/ZAZCAR PLANT
ZAPOROZHIA, UKRAINE
BOILER OPERATING MEASUREMENTS

Time 02-Mar-95	Gas Flow (m3/hr)	Steam Flow (T/hr)	Steam Press.	Combustion Chamber Press. (mm w c.)	Press After Boiler (mm w.c.)	Exhaust Temp. (deg C)	Comments
Boiler #2							
15:00	700	15	5	-2.5	NA	250	
15:10	700	15	5	-2.5	NA	250	Economizer 2 Measurement
15:45	520	12.2	4.5	-2.5	NA	230	
16:10	520	12.2	4 5	-2.5	NA	230	
16:30	520	12.2	4 5	-2.5	NA	225	Stack Measurement
17:00	520	12.2	4 5	-2.5	NA	225	Economizer 1 Measurement
Boiler #3							
15:00	480	13	4 8	-3	-25	320	
15:10	480	13	4.8	-3	-25	320	Economizer 2 Measurement
15:45	460	14.5	4.8	-3	-25	340	Stack Measurement
16:10	460	14.5	4.8	-3	-25	340	
16:30	460	14.5	4.8	-3	-25	340	
17:00	460	14.7	4 8	-3	-77	340	Economizer 1 Measurement
Boiler #4							
15:00	620	13		-3	-25.5	340	Stack Measurement
15:10	620	13		-3	-25.5	340	Economizer 2 Measurement
15:45	700	13.6		-2.5	-25.5	360	
16:10	710	13.2		-2	-22.5	357	
16:30	710	13.2		-2	-22.5	357	
17:00	710	13.4		-2	-22.5	357	Economizer 1 Measurement
Boiler #5							
15:00	520	10.3	5.5	-2.5	-10	280	Stack Measurement
15:10	630			-3			Economizer 2 Measurement
15:45	680	10.4	5.5		-8	320	
16:15		11.9	5.5		-14	315	
16:25							
16:30	680	11.9	5.5		-14	315	Economizer 1 Measurement
17:00	500	12			-14	318	
03-Mar-95							
Boiler #2							
10:30	54	12.5	4 2	-2 5	-30	225	
10 40	53	12.5	4 1	-2.5	-27	221	
10:45	53	12.5	4 1	-2.5	-20	210	
11:00	53	12.5	4.1	-2.5	-19	190	

TABLE "A–2" (continued)
KOMMUNAR/ZAZCAR PLANT
ZAPOROZHIA, UKRAINE
BOILER OPERATING MEASUREMENTS

Time 09–Mar–95	Gas Flow (m3/hr)	Steam Flow (T/hr)	Steam Press.	Combustio Chamber Press. (mm w.c.)	Press After Boiler (mm w c.)	Exhaust Temp. (deg C)	Comments
Boiler #2							
10:10	670	13	NA	–3	–18	200	
10:35	670	13	NA	–3	–18	200	
14:57	680	12.5	NA	–2.5	–20	200	
15:10	680	12.5	NA	–2.5	–20	200	
Boiler #3							
10:10	625	13	NA	–3	–22	320	
10:35	630	13.1	NA	–3	–22	320	
14:57	625	14.5	NA	–3	–25	320	
15:10	625	14.5	NA	–3	–25	320	
Boiler #4							
10:10	820	13	NA	–2.5	–22	360	
10:35	820	13.1	NA	–2.5	–22	360	
14:57	875	13.9	NA	–2.5	–30	370	
15:10	875	13.9	NA	–2.5	–30	370	
Boiler #5							
10:10	630	13	NA	–2.5	–8	270	
10:35	625	13.1	NA	–2.5	–8.5	270	
14:57	750	14.2	NA	–2.5	–8	255	
15:10	750	14.2	NA	–2.5	–8	255	

TABLE "A–3"
KUMMUNAR/ZAZ ENERGY SAVINGS CALCULATIONS

Carbon Monoxide losses
Volume flue gas/volume of natural gas = 10 5 ft3/ft3 at stoichiometric Combustion

On March 9, 1995, Economizer 1 was operating with 3274 vppm CO
Flue gas Volume in Economizer 1

52/2 T/hr steam * 2205 lb/T =	57300	lb steam/hr (2 boilers)
57300 lb steam/hr * 1011Btu/lb	57930300	Btu/hr into steam
57 9 MMBtu/hr/0 661 (Efficiency)	87640393	Btu/hr firing rate
87 6 MMBtu/hr/983 Btu/SCF	89156	SCFh natural gas
89200 SCFh*(10 5+9 5*0 69 excess air)	1520556	SCFh flue gas
1,521,000SCFh*3274 vppm CO/1000000	49783	SCFh carbon monoxide
49800 SCFh CO* 321 Btu/SCF	15980348	Btu/hr combustion loss
Instrument Saturated >	18 2%	Combustion loss

Efficiency = 0 877 (Bacharach) – 0 182 (Combustion Loss) – 0 03 (Wall & Blowdown Losses = 0 665

On March 9, 1995, Economizer 2 was operating with 1994 vppm CO

52/2 T/hr steam * 2205 lb/T =	57300	lb steam/hr (2 boilers)
57300 lb steam/hr * 1011Btu/lb	57930300	Btu/hr into steam
57.9 MMBtu/hr/0 664 (Efficiency)	87244428	Btu/hr firing rate
87 2 MMBtu/hr/983 Btu/SCF	88753	SCFh natural gas
88750 SCFh*(10 5+9 5*1 46 excess air)	2162916	SCFh flue gas
2,163,000SCFh*1994 vppm CO/1000000	43129	SCFh carbon monoxide
43100 SCFh CO* 321 Btu/SCF	13844265	Btu/hr combustion loss
	15 9%	Combustion loss

Efficiency = 0 853 (Bacharach) – 0 159 (Combustion Loss) – 0 03 (Wall and Blowdown Loss = 0 664
Average Combustion Loss From Carbon Monoxide 17 1%

Average Excess Air Efficiency	84 7%	Economizer 1 March 9
Includes 3% wall and blowdown losses	82 3%	Economizer 2 March 9
	82 0%	Economizer 2 March 2
	83.0%	Economizer 1 March 2
	83 0%	Average Efficiency
Calculated Optimum	87 4%	Assumes 20% excess air at economizer
Available Improvement	4 4%	
Total Potential Energy Savings	21 5%	

Average Savings

Verbal communication from plant		$1,540,000	USD 1994 Fuel Bill for Boilers	
$1,540,000 US * 0 215	$63/1000 m3	$331,100	Plant wide	Ukrainian Prices
$1,810,000 US * 0 215	$74/1000 m3	$388,911	Plant wide	World Prices

TABLE "A–3" (continued)
KUMMUNAR/ZAZ ENERGY SAVINGS CALCULATIONS

Carbon Monoxide losses.
Volume flue gas/volume of natural gas = 10 5 ft3/ft3 at stoichiometric Combustion

On March 9, 1995, Economizer 2 was operating with 258 vppm CO after boiler adjustments
Flue gas Volume in Economizer 2

52/2 T/hr steam * 2205 lb/T =	57300	lb steam/hr (2 boilers)
57300 lb steam/hr * 1011BTU/lb	57930300	Btu/hr into steam
57 9 MMBTU/hr/0 804 (Efficiency)	72052612	Btu/hr firing rate
72 1 MMBTU/hr/983 BTU/SCF	73299	SCFh natural gas
73300 SCFh*(10 5+9 5*1 25 excess air)	1640058	SCFh flue gas
1,640,000 SCFh*258 vppm CO/1000000	4231	SCFh carbon monoxide
4230 SCFh CO* 321 BTU/SCF	1358263	Btu/hr combustion loss
	1 9%	Combustion loss

Efficiency = 0 853 (Bacharach) – 0 019 (Combustion Loss) – 0 03 (Wall & Blowdown Losses = 0 804

Average Combustion Loss From Carbon Monoxide	0 9%	
Average Excess Air Efficiency	84 7%	Economizer 1 March 9
Includes 3% wall and blowdown losses	82.3%	Economizer 2 March 9
	82 0%	Economizer 2 March 2
	83 0%	Economizer 1 March 2
	83 0%	Average Efficiency
Calculated Optimum	87 4%	Assumes 20% excess air at economizer.
Available Improvement	4 4%	
Average Combustion Loss From Carbon Monoxide	0 9%	
Average Excess Air Efficiency	84 7%	Economizer 1 March 9
Includes 3% wall and blowdown losses	82.3%	Economizer 2 March 9
	82 0%	Economizer 2 March 2
	83 0%	Economizer 1 March 2
	83 0%	Average Efficiency
Calculated Optimum	87 4%	Assumes 20% excess air at economizer.
Available Improvement	4.4%	
Total Potential Energy Savings	5 3%	

Average Savings

Verbal communication from plant		$1,540,000	USD 1994 Fuel Bill for Boilers	
$1,540,000 US * 0 215	$63/1000 m3	$81,620	Plant wide	Ukrainian Prices
$1,810,000 US * 0 215	$74/1000 m3	$95,871	Plant wide	World Prices

ECO-03

Isolate Nonoperating Boilers For Shutdowns Greater Than Two Months to Reduce Excess Air

DESCRIPTION OF EXISTING EQUIPMENT AND OPERATING CONDITIONS

Analyses of stack gases with a portable analyzer showed that the boilers had high carbon monoxide emissions and high excess air.

DESCRIPTION OF PROPOSED MODIFICATIONS

Better control of excess air is needed promptly to conserve energy. The quantity of energy that is currently being lost is estimated in the calculations given below.

ENERGY SAVINGS CALCULATION

Based on the measurements the boilers averaged 66% efficiency at the economizer outlet. After trimming the boilers averaged 83.0% efficiency at the economizer outlet. A 9% efficiency improvement is forecast for this measure. When the ECO-1 and ECO-2 and ECO-3 are combined, the plant should be able to operate consistly with 86% or better efficiency. See tables "A-1" through "A-3", following ECO-02.

Average Steam flow:	28.8 metric ton/hr
Enthalpy added to steam:	
1195.5 Btu/lb saturated x 1.055 kJ/Btu x 2.205 kg/lb	= 2781 kJ/kg
182.0 Btu/lb saturated liquid at 100 °C x 1.055 x 2.205	= 423 kJ/kg
	= 2358 kJ/kg
Total heat input to steam:	
2358 kJ/kg x 28.8 T/h x 1000 kg/T	= 67,900,000 kJ/hr
	= 67.9 GJ/hr
Heat input to boiler:	
67.9 GJ/hr/0.84 (efficiency) before implementation	= 80.83 GJ/hr
67.9 GJ/hr/0.86 (efficiency) after implementation	= 78.95 GJ/hr
Total estimated savings	= 1.88 GJ/hr
8760 hours * 1.88 GJ/hr	= 16,500 GJ saved per year
	= 15.6 Million Btu per year
16,500x1,000,000/36652	= 449,000 m^3/yr saved

ECO-03 (continued)

449,000 x \$63 US/1000 m^3	Ukrainian Price	= \$ 28,300 USD/yr
449,000 x \$74 US/1000 m^3	World Price	= \$ 33,200 USD/yr

Project to isolate boiler #1

Sheet Metal	= \$ 2,000
Blanking Plate for fuel gas	= \$ 200
Installation Costs	= \$ 500
Estimated Project Cost	= \$ 2,700 US

Simple Payback = Cost = 2,700 x 365 = 34 days
Local Energy Prices Savings 28,300

Simple Payback = Cost = 2,700 x 365 = 30 days
Worldwide Energy Prices Savings 33,200

ECO-04

Repair Insulation on Boiler Feed Water Lines

DESCRIPTION OF EXISTING EQUIPMENT AND OPERATING CONDITIONS

Missing and badly deteriorated insulation on the boil feed water lines were observed during the audit.

DESCRIPTION OF PROPOSED MODIFICATIONS

Add and repair boiler feed water line insulation to conserve energy. The quantity of energy that is currently being lost is estimated in the calculations given below.

ENERGY SAVINGS CALCULATION

About seven (7) meters of 150 mm diameter boiler feed water piping has lost insulation. An InfraRed sensing instrument read about 100 °C. At this temperature 37.5 mm thick insulation saves 9.4 kJ/hr.meter of length.

9.4 kJ/hr.meter x 7 meters		= 65.8 kJ/hr
65.8 kJ/hr x 8760 hr		= 576,100 kJ/year
		= 546 Million Btu per year
546 x 1,000,000/36,652		= 15,700 m^3/yr saved
15,700 x \$63 US/1000 m^3	Ukrainian Price	= \$ 990 USD/yr
15,700 x \$74 US/1000 m^3	World Price	= \$ 1,162 USD/yr

Project to insulate boiler feed water line.

Insulation:

Cost of insulation \$32.50 /meter x 7 meters	= \$ 227
Installation Costs	= \$ 200
Estimated Project Cost	= \$ 427 US

Simple Payback Ukrainian Prices = $\frac{\text{Cost}}{\text{Savings}}$ = $\frac{227}{990}$ x 12 = 2.75 months

Simple Payback Prices = $\frac{\text{Cost}}{\text{Savings}}$ = $\frac{227}{1,162}$ x 12 = 2.34 months World

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ECO-05

Fix Rather Large Leak from Steam Valve in Main Building.

DESCRIPTION OF EXISTING EQUIPMENT AND OPERATING CONDITIONS

In the main building a large steam leak is clearly visible from a valve in a steam line.

DESCRIPTION OF PROPOSED MODIFICATIONS

The leak should be repaired, as soon as possible, in order to conserve energy. The quantity of steam, energy and money that is currently being lost is estimated in the calculations given below.

ENERGY SAVINGS CALCULATION

Steam pressure is approximately 2.3 bar (33 psig). The leak is large, estimated to be approximately 50 kg/hr (110 lbs/hr). If the leak continues for 5 days per week, 2 shifts per day and 260 days per year, the total annual steam loss will be:

$$\frac{(110)\ (16)\ (260)}{2{,}205} = 208 \text{ metric tons}$$

Approximate local price for steam is 450,000 Ukrainian coupons/metric ton or $ 3.04 per metric ton

Current Annual Loss = (3.04) (208) = $ 630
(Local Price)

Current Annual Loss = (4.00) (208) $\frac{(2{,}205)}{(1{,}000)}$ = $ 1,830
(Worldwide Price)

Latent Heat of Steam = 925 Btu/lb

Yearly Energy That Could Be Saved = (925) (208) (2,205)
= 0.42 billion Btu (440 GJ)

440 x 1,000,000/36,652 = 12,000 m^3/yr

Estimated Project Cost to Fix Steam Leak:

Negligible Cost, say $ 100

ECO-05 (continued)

Simple Payback Local Energy Prices	=	Cost / Savings	=	100 x 12 / 630	=	1.9 months
Simple Payback Worldwide Energy Prices	=	Cost / Savings	=	100 x 12 / 1,830	=	20 days

ECO-06

Install Automatic Flow Controllers on Large Users of Steam.

DESCRIPTION OF EXISTING EQUIPMENT AND OPERATING CONDITIONS

Currently all of the steam users in the plant are controlled manually. This method of control does not insure that the proper quantity of steam is being provided to each user and in most cases the quantity provided is too large.

DESCRIPTION OF PROPOSED MODIFICATIONS

It is recommended that for the largest users of steam in the plant, automatic flow controllers be installed to insure that the proper quantity of steam is, in all cases, delivered to the user.

Four specific users that are recommended at this time are the following:

Workshop	Steam Pipe Diameter	Steam Pressure, psig	Steam Consumption Metric Tons/Hour
Metals Coating	200 mm (8 inch)	1.5	9
Mechanical	100 mm (4 inch)	1.5	3
Painting	200 mm (8 inch)	1.8	3
	150 mm (6 inch)	1.8	3
		Total	18

ENERGY SAVINGS CALCULATION

A 10% efficiency improvement in the utilization of steam is forecast for this measure.

10% of 18 metric tons per hour = 1.8 metric tons/hour
Annual steam savings = (1.8) (16) (260) = 7,500 metric tons

Annual Savings (Local Price) = (3.04) (7,500) = $ 22,800

ECO-06 (continued)

Annual Savings (Worldwide Price)	=	(4.00) (7,500) $\frac{(2,205)}{(1,000)}$	=	$ 66,200

Yearly Energy Saved	=	(925) (7,500) (2,205)
	=	15.3 billion Btu (16,100 GJ)

16,100 x 1,000,000/36,652	=	439,000 m^3/yr

Estimated Project Cost to Purchase and Install Valves:

$ 93,300

Simple Payback Local Energy Prices	=	$\frac{\text{Cost}}{\text{Savings}}$	=	$\frac{(93,300)}{22,800}$	=	4 years
Simple Payback Worldwide Energy Prices	=	$\frac{\text{Cost}}{\text{Savings}}$	=	$\frac{(93,300)}{66,200}$	=	1.4 years

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ECO-07

Minimize Vent Losses on Opened Condensate Collection System.

DESCRIPTION OF EXISTING EQUIPMENT AND OPERATING CONDITIONS

In the condensate collection system there is a buried collector that collects non-pumped condensate from various users and also collects fresh make-up water for the boilers. The collector does not have a cover and has a one meter in diameter opening which vents a rather large quantity of steam to the atmosphere.

DESCRIPTION OF PROPOSED MODIFICATIONS

A cover needs to be installed on the collector, as soon as possible, in order to present the loss of steam and thus conserve energy. The cover should be one meter in diameter and made of carbon steel in a way which is similar or identical to a manway. The cover is to rest ontop of the hole and not be mechanically attached. A cage made of bars is to surround the cover on all sides to prevent it from moving more than a few tenths of a meter in any direction should the collector be overpressured. A 150 mm diameter vent should be installed in the center of the cover to allow some steam to escape, as may be required, during normal operation and also during situations of higher pressure.

ENERGY SAVING CALCULATION

It is estimated that 0.5 metric tons per hour of steam is lost through the opening in the collector.

On a yearly basis this corresponds to:

$$(0.5)\ (16)\ (260) = 2{,}080 \text{ metric tons}$$

Annual Savings (Local Price) = (3.04) (2,080) = $ 6,300

Annual Savings (Worldwide Price) = $(4.00)\ (2{,}080)\ \frac{(2{,}205)}{(1{,}000)}$ = $ 18,400

Yearly Energy Saved = (925) (2,080) (2,205)
= 4.2 billion Btu (4,400 GJ)

4,400 x 1,000,000/36,652 = 120,000 m^3/yr

ECO-07 (continued)

Estimated Project Cost to Install Cover and Cage on Collector:

Estimated Cost $ 500

Simple Payback Local Energy Prices	=	Cost Savings	=	500 x 365 6,300	= 29 days	
Simple Payback Worldwide Energy Prices	=	Cost Savings	=	500 x 365 18,400	= 10 days	

ECO-08

Install Automatic Flow Controller on Large Users of Compressed Air.

DESCRIPTION OF EXISTING EQUIPMENT AND OPERATING CONDITIONS

Currently all of the compressed air users in the plant are controlled manually. This method of control does not insure that the proper quantity of compressed air is being provided to each user and in most cases the quantity provided would be too large.

DESCRIPTION OF PROPOSED MODIFICATIONS

It is recommended that for the largest users of compressed air in the plant, automatic flow controller be installed to insure that the proper quantity of compressed air is, in all cases, delivered to the user.

Three specific users that are recommended at this time are the following:

Workshop	Estimated Control Valve Size
Metal Pressing	150 mm (6 inch)
Painting	250 mm (10 inch)
Welding	250 mm (10 inch)

ENERGY SAVINGS CALCULATION

A 10% efficiency improvement in the utilization of compressed air is forecast for this measure. This corresponds to a savings of 755 KW for all operating compressors in the four stations.

Annual kWh Savings = (755) (16) (260) = 3.1 million kWh

Local Price of Electricity = 0.0155 $/kWh

Worldwide Price of Electricity = 0.05 $/kWh

Annual Savings = (0.0155) (3.1 million) = $ 48,100
(Local Price)

Annual Savings = (0.05) (3.1 million) = $ 155,000
(Worldwide Price)

ECO-08 (continued)

Estimated Project Cost to Purchase and Install Valves:

$ 72,100

Simple Payback Local Energy Prices	=	Cost / Savings	=	(72,100) / 48,100	=	1.5 years
Simple Payback Worldwide Prices	=	Cost / Savings	=	(72,100) x 12 / 155,000	=	6 months

ECO-09

Shutdown Equipment that Does Not Already Need to Run.

DESCRIPTION OF EXISTING EQUIPMENT AND OPERATING CONDITIONS

The plant only operates two shifts per day. These shifts are from 7:00 a.m. to 3:30 p.m. and from 3: p.m. to 11:40 p.m. Thus during the period from 11:40 p.m. to 7:00 a.m. the plant should basically not be in operation. Nevertheless, we had information that showed that there was a fairly high consumption of electricity during this late evening period. This was the result of certain items of equipment that were not completely shutdown during the night. These items include the turbo compressor for compressed air, the electrical annealing furnaces and the ventilation system in the painting chamber. Data taken during the evening of March 9 and 10, 1995 using a Dranetz 808A Power Analyzer shows that the power consumption for a portion of the plant which included half of Compressor Station Number 4, half of the Paint Shop and half of the Welding Shop dimished only from about 3.2 MW to 0.8 MW during the late night period. This indicates that certain items of equipment, which were still consuming approximately 25% of the normal electrical consumption, were still running during this period.

DESCRIPTION OF PROPOSED MODIFICATIONS

We recommended that a survey be made by plant personnel, using the Dranetz 808A Power Analyzer, to pinpoint exactly which items of equipment in the entire plant are running during the late evening hours and during other periods, such as week-ends and holidays, when they should not be operating.

ENERGY SAVINGS CALCULATION

The normal electrical consumption of the plant is 50 MW.

If 25% of this figure could be saved during late evening hours, then the yearly savings would be:

(0.25) (50) (8) (260) = 26,000 MWh/yr

Local Price of Electricity	=	0.0155 $/KWh
Worldwide Price of Electricity	=	0.05 $/KWh

ECO-09 (continued)

Annual Savings (Local Price)	=	(26,000) (1,000) (0.0155)	=	$ 403,000
Annual Savings (Worldwide Price)	=	(26,000) (1,000) (0.05)	=	$ 1,300,000

Estimated Project Cost:

Dranetz 808A	=	$ 13,100
Plant Labor for Survey	=	$ 1,000
TOTAL		$ 14,100

Simple Payback Local Energy Prices = $\frac{\text{Cost}}{\text{Savings}} = \frac{14{,}100 \times 365}{403{,}000} =$ 13 days

Simple Payback Worldwide Energy Pries = $\frac{\text{Cost}}{\text{Savings}} = \frac{14{,}100 \times 365}{1{,}300{,}000} =$ 4 days

B \ECO09 CP

ECO-10

Reduce Excess Lighting and Improve Dimly Lit Areas in Certain Parts of Automobile Final Assembly Building.

DESCRIPTION OF EXISTING EQUIPMENT AND OPERATING CONDITIONS

The overall lighting system is mostly of flourescent fixtures.

DESCRIPTION OF PROPOSED MODIFICATIONS

Replace fixtures in Auto-Finishing Plant and other key areas with high pressure sodium fixtures with color co-ordinated lamps for good rendition.

ENERGY SAVINGS CALCULATION

The Auto-Finishing area fixtures can be changes to more efficient fixtures. The estimated project cost to do this is $ 25,000. The anticipated annual cost saving is projected at $ 1,000 per year, based on worldwide prices and $ 310 per year, based on local prices. The annual energy savings is 20,000 KW. The payback, based on local prices is 81 years and based on worldwide prices is 2.5 years. This ECO is not attractive.

ECO-11

Institute Improved Energy Management Procedures

DESCRIPTION OF EXISTING EQUIPMENT AND OPERATING CONDITIONS

- The plant does not have a single individual who is responsible for energy conservation, but does have a committee known as the "Bureau for Energy Usage."

- The plant does not have a yearly budget which is set aside for energy conservation projects.

- It is extremely difficult to get approval from the "Ruling Body" for energy conservation projects.

- The plant has no criteria, such as payback or discounted cash flow, for making investments in the plant to conserve energy.

- Basic maintenance is performed, except where replacement parts are not available or where the implementation of the repair would be extremely costly.

DESCRIPTION OF PROPOSED MODIFICATIONS

A strong chairman shall be appointed for the "Bureau for Energy Usage" who will be responsible to develop an appropriate agenda and proper planning for energy conservation implementation. The highest proprietary must be given to the establishment of a yearly budget for energy conservation. A criteria such as a 3 year payback or 15% discounted cash flow should be used for making decisions as to whether or not to invest in an energy conservation project and also to convince the "Ruling Body" of its merit.

ENERGY SAVINGS CALCULATION

We predict an overall efficiency improvement of 10% in the overall utilization of energy, if these recommendations are implemented.

Given below is an estimate of the yearly cost in 1994, based on local prices, for the following types of energy:

- Natural Gas

- Mazut

- Electricity

ECO-11 (continued)

ESTIMATE OF THE YEARLY COST FOR NATURAL GAS IN 1994

Present Cost of Natural Gas	=	\$ 63.00 per 1000 meter^3
1994 Natural Gas Consumption	=	\$ 42.5 million m^3
Estimate of 1994 Yearly Cost	=	(63) (42,500)
	=	\$ 2,677,500

ESTIMATE OF THE YEARLY COST FOR MAZUT IN 1994

Present Cost of Mazut	=	\$ 43.92 per metric ton
1994 Mazut Consumption	=	592 metric tons
Estimate of 1994 Yearly Cost	=	(43.92) (592)
	=	\$ 26,000

ESTIMATE OF THE YEARLY COST FOR ELECTRICITY IN 1994

	Electrical Consumption in kWh	Electrical Demand in KW	Electrical Reactive in rkVah	Total Cost
Consumption for Year	203.4 million	594,000	131.2 million	-
Cost Per Unit in \$	0.0155	1.81	0.0019	-
Yearly Cost	\$ 3,150,000	\$ 1,075,000	\$ 249,300	\$ 4,474,300

ECO-11 (continued)

SUMMARY OF 1994
ENERGY COSTS

Electricity	$ 4,474,300
Natural Gas	$ 2,677,500
Mazut	$ 26,000
TOTAL	$ 7,177,800

If there is a 10% improvement in efficiency, the overall savings, based upon local prices, would be $ 718,000. For worldwide prices this would be approximately $ 2,000,000.

The annual energy savings would be:

3.8 trillion Btu/hr x 10% = 0.38 trillion Btu/hr (400,900 GJ)

400,900 x 1,000,000/36,652 = 10,938,000 m^3/yr

The cost of the program would be negligible and the payout immediate.

ECO-12

Institute Energy Conservation Training of Plant Personnel.

DESCRIPTION OF EXISTING EQUIPMENT AND OPERATING CONDITIONS

At present the plant's employees have not received any training in the principles of energy conservation.

DESCRIPTION OF PROPOSED MODIFICATIONS

An energy conservation training program, consisting of a minimum of two, 2-hour, training sessions, shall be implemented for all plant operating personnel. The program should emphasize how each individual should look for ways to conserve energy, as he is carrying out his job. This program may be given by in-house experts, which is the most economical approach, or by specialists from outside the plant.

ENERGY SAVINGS CALCULATION

See calculation above, on ECO-11, for the total yearly energy cost for the plant in 1994.

If we predict a 5% savings for the training program, the yearly savings, based upon local prices, would be $ 359,000.

For worldwide prices this would be approximately $ 1,000,000.

The annual energy savings would be:

3.8 trillion Btu/hr x 5% = 0.19 trillion Btu/hr (200,500 GJ)

200,500 x 1,000,000/36,652 = 5,470,000 m^3/yr

The cost of the program would be negligible and the payout immediate.

ECO-13

Improve Power Factor Caused By Induction Motors during Robotics Welding.

DESCRIPTION OF EXISTING EQUIPMENT AND OPERATING CONDITIONS

The overall power system operates with an average power factor of 0.7 lag. The main contributors to this level are the Robotic welding machines induction motors.

DESCRIPTION OF PROPOSED MODIFICATIONS

Reactive power use amounted to 131,200,480 KVARH per year in 1994. This equates to approximately 2,000 KVAC of correction to achieve a 0.95 lag.

ENERGY SAVINGS CALCULATION

The worldwide cost of reactive power is $ 0.006/KVARH

The local cost of reactive power is $ 0.0019/KVARH

2000x260x16x0.006 = $ 49,900 per year, worldwide cost
2000x260x16x0.0019 = $ 15,800 per year, local cost

2000 KVAC arranged in a bank of 10 x 200 KVAC units, switchable and attached to the 6.6 KV system, is estimated as $ 75,000 installed. The payoff period is 4.8 years based on local costs and 1.5 years based on worldwide costs.

The annual energy savings is 8.3 million KVAR.

This ECO is moderately attractive.

ECO-14

Install Variable Speed Drive on One or More Turbo Compressor Motors.

DESCRIPTION OF EXISTING EQUIPMENT AND OPERATING CONDITIONS

Currently, the power consumption of the existing compressors equates to 3 of the 4 in operation during the working shifts.

DESCRIPTION OF PROPOSED MODIFICATIONS

Installation of variable speed drives on the air compressors is estimated to reduce by 20% the existing electrical usage. The current operating level is 78% of kill load of the motor evaluated. Assuming equal share with the other two motors, then large savings can be anticipated by installing Variable Speed Drives on the motors.

ENERGY SAVINGS CALCULATION

Present Operation 3 x 78% of 1750 KVA @ 0.99pf = 4,054 KW.

20% reduction in total load with installation of variable speed drives:

Savings = 0.2 x 4,054 = 810 KW or 3.4 million KW annually

Typically on a system such as this, the operating costs for energy use can be decreased by use of Variable Speed Drives to accommodate the variations in compressed air usage during the working period.

Based on local prices, this equates to an annual savings of (810) (0.0155) (260) (16) = $ 52,200

This equates to an energy savings of $ 168,500 per year @ $ 0.05/kWhr. on 2 shifts.

Estimated Project Cost of Four (4) Variable Drive Units and Four New Motors is:

$ 1,000,000

$$\text{Simple Payback Local Energy Prices} = \frac{\text{Cost}}{\text{Savings}} = \frac{1{,}000{,}000}{52{,}200} = 19.1 \text{ years}$$

$$\text{Simple Payback Worldwide Energy Prices} = \frac{\text{Cost}}{\text{Savings}} = \frac{1{,}000{,}000}{168{,}500} = 5.9 \text{ years}$$

This ECO is not attractive.

B \ECO14.CP

ECO-15

Add or Replace Non-Operating Steam Traps.

DESCRIPTION OF EXISTING EQUIPMENT AND OPERATING CONDITIONS

The steam system nominally handles 50 metric tons per hour of steam, as produced by the operating boilers. Much of the steam is used in condensing services which should employ properly functioning steam traps. However, at present, most of the steam traps do not work and in addition may services which should have steam traps, currently do not. The plant uses mostly thermodynamic steam traps which they now believe do not work efficiently at the low pressure level of 1 to 1.5 bar which always exists. They would like to use another type of steam trap instead.

The average trap currently handles 1 metric ton per hours of steam. The minimum trap handles 0.5 metric ton per hour and the maximum trap handles 1.5 metric tons per hour.

DESCRIPTION OF PROPOSED MODIFICATIONS

It is recommended that the plant acquire approximately 150 new Inverted Bucket type steam traps. This will cover both the steam traps that currently do not work and the services which currently do not have steam traps, but do require them.

ENERGY SAVINGS CALCULATION

We conservatively estimate that the new installation of 150 steam traps will properly condense and recover 20% of the current steam load or 10 metric tons/hr.

Annual Steam Savings	=	(10) (16) (260)	=	41,600 metric tons
Annual Savings (Local Price)	=	(3.04) (41,600)	=	$ 126,500
Annual Savings (Worldwide Price)	=	(4.00) (41,600)	=	$ 166,400
Yearly Energy Savings	=	(925) (41,600) (2,205)	=	84.9 billion Btu (89,600 GJ)
89,600 x 1,000,000/36,652	=	2,445,000 m^3/yr		

ECO-15 (continued)

Estimated project Cost to Purchase and Install 150 Steam Traps:

$ 107,600

Simple Payback Local Energy Prices	=	Cost / Savings	=	(107,600) (12) / 126,500	=	10.2 months
Simple Payback Worldwide Prices	=	Cost / Savings	=	(107,600) (12) / 166,400	=	7.8 months

ECO-16

Collect Additional Condensate and Recycle to Boilerhouse.

At present, only 30% of the condensate produced in the plant is recovered and the remainder goes to the sewer as hot water. In terms of flow quantities, of the 50 metric tons per hour ton of steam that is produced by the boilers, 15 metric tons per hour is recovered as condensate and 35 metric tons per hour is lost.

DESCRIPTION OF PROPOSED MODIFICATIONS

Of the 35 metric tons per hour that is lost, some of it is not condensed and thus can not be recovered. We will assume that it is possible to recover an additional 25 metric tons per hour. This will give us a total recovery of 80% or 40 metric tons per hour.

In addition to some new piping, the new equipment that would be needed is the following:

- Condensate Collection Drum
- Condensate Pump and Spare
- Vent Condenser

ENERGY SAVINGS CALCULATION

25 metric tons per hour of condensate recovered would represent the following annual saving:

$$(25)\ (16)\ (260) = 104{,}000 \text{ metric tons/year}$$

Condensate is typically valued at 10% of the steam price. This corresponds to:

Local Condensate Price $= (0.1)\ (3.04) = 0.30$ \$/metric ton

Worldwide Condensate Price $= (0.1)\ (4.00) = 0.40$ \$/1000 lbs.

Annual Savings (Local Price) $= (0.30)\ (104{,}000) = \$\ 31{,}200$

Annual Savings (Worldwide Price) $= (0.40)\ (104{,}000)\ \frac{(2.205)}{1{,}000} = \$\ 91{,}700$

ECO-16 (continued)

Yearly Energy Savings	=	(10%) (925) (104,000) (2,205)	=	21.2 billion Btu (22,400 GJ)

22,400 x 1,000,000/36,652 = 612,000 m^3/yr

Estimated Project Cost to Purchase and Install System:

$ 206,000

Simple Payback Local Energy Prices	=	Cost / Savings	=	206,000 / 31,200	=	6.6 years
Simple Payback Worldwide Prices	=	Cost / Savings	=	(206,000) / 91,700	=	2.2 years

B.\ECO16 CP

BASIS OF ESTIMATED INVESTMENT COSTS

The following forms the basis of the estimated Investment Costs contained in this section:

- Current day instant execution philosophy with no forward escalation.
- Normal 40-hour work week with no premium time. Construction assumed to be performed by plant personnel.
- Contingency has not been included.
- Costs have been adjusted to reflect the Ukraine location. It is assumed that the rate of currency exchange is negating the effect of local inflation.
- These estimates have an accuracy of ±30%.

APPENDIX "B"

Photographs of Facility and Equipment

List of Photographs:

1. Entrance to Plant
2. Boiler and Steam System Schematic Flow Diagram
3. Boiler Front Including Burners
4. Boiler Instrument Panel
5. Installation of Flue Gas Sampling Probe
6. Bacharach Combustion Gas Analyzer
7. BFW Lines Missing Insulation
8. Air Distribution Duct to Boilers
9. Gas Control Valve for Boiler
10. Steam Pressure Reducing Station (8 Bar to 2.5 Bar)
11. Mazut Tank, Stacks for Hot Water Heater (Foreground) and Boilers (Background)
12. Steam Venting from Condensate Tank
13. Insulation Needing Repair
14. Insulation Needing Replacement
15. Air Compressor (1500 KW)
16. Compressed Air Receivers for Metal Pressing Operation
17. Metal Pressing Operation
18. Electrical Measurements
19. Robotics Control Panel
20. Robotic Welding
21. Stack of Car Frames
22. Automobile Assembly

List of Photographs: (continued)

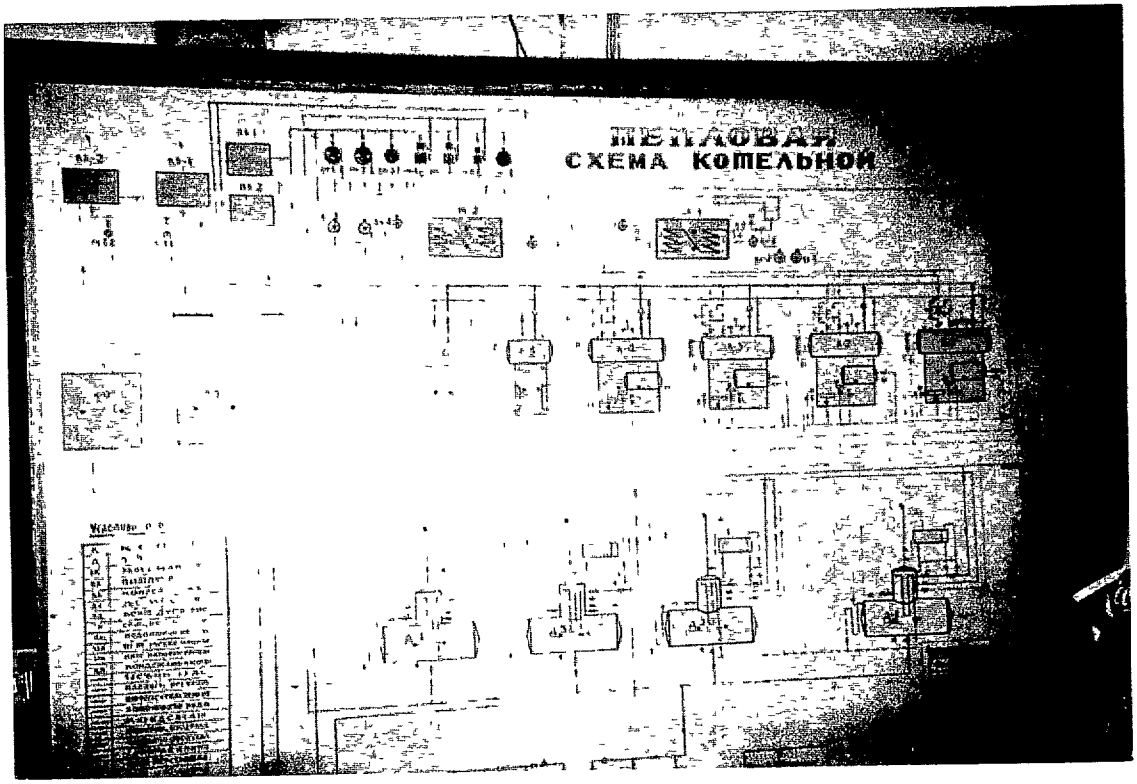
23. Painting Operation

24. Automobile Assembly Engine Installation

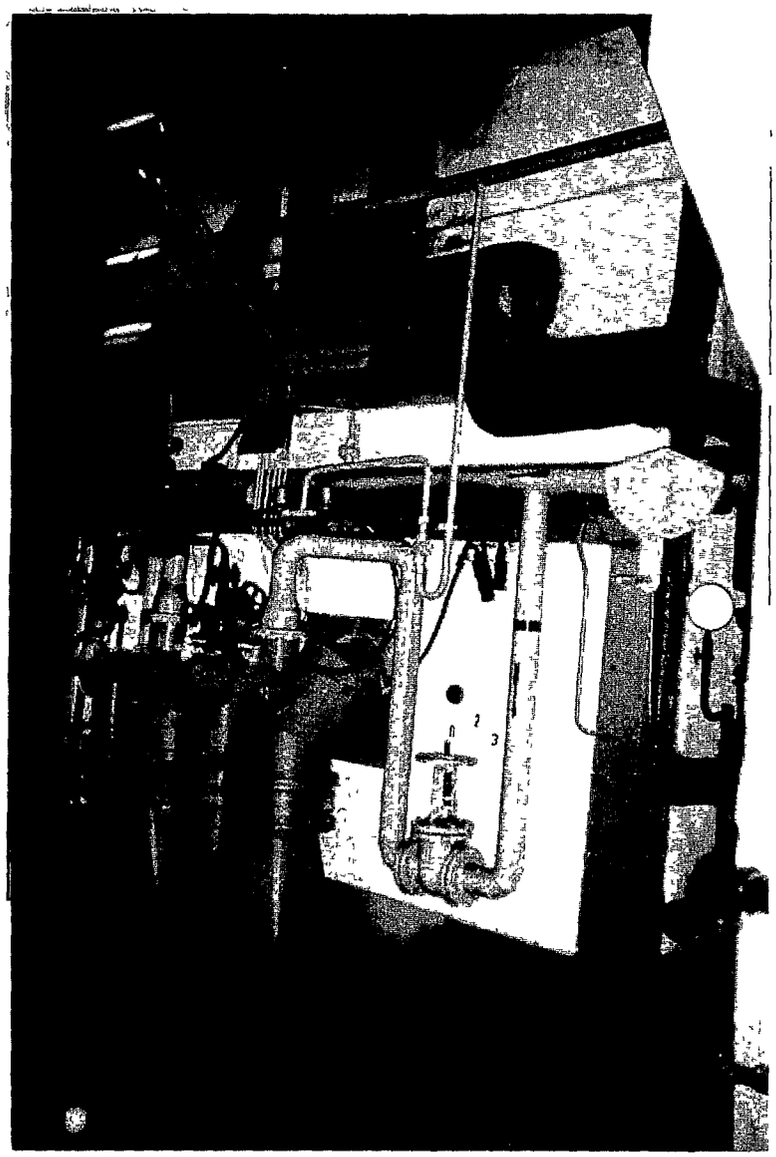
25. Automobile Assembly Line

26. Final Assembly Line

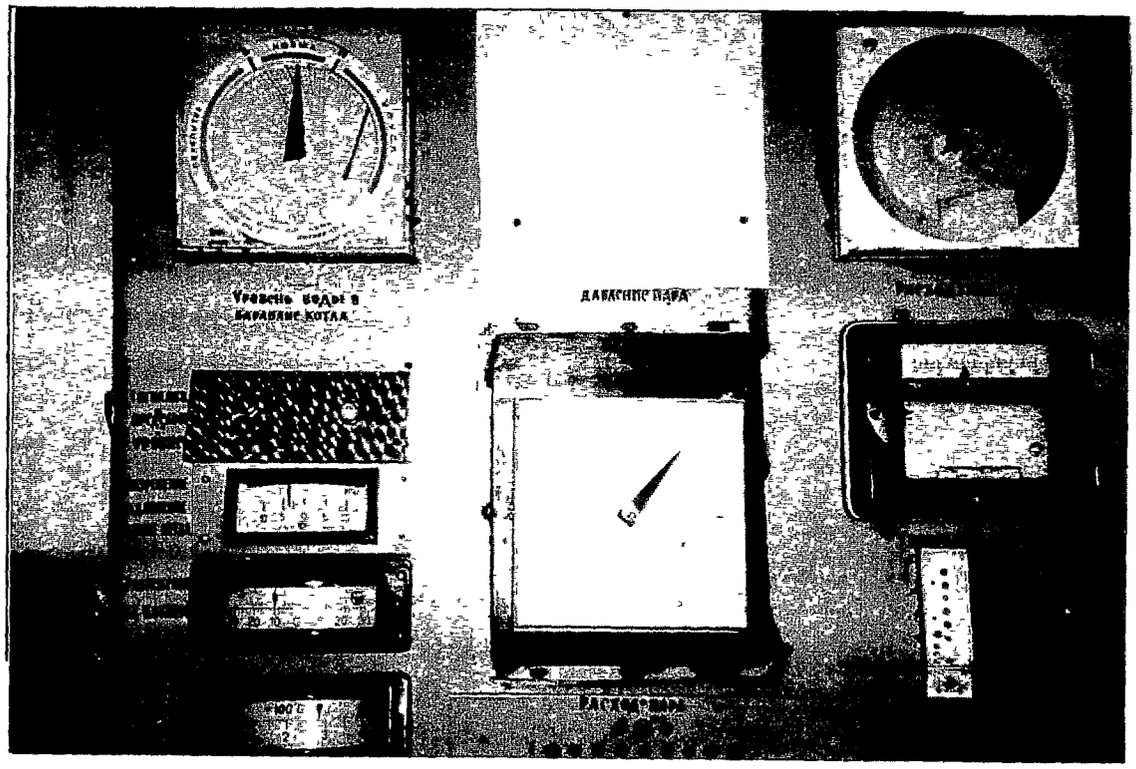
1 Entrance to Plant



2 Boiler and Steam System Schematic Flow Diagram



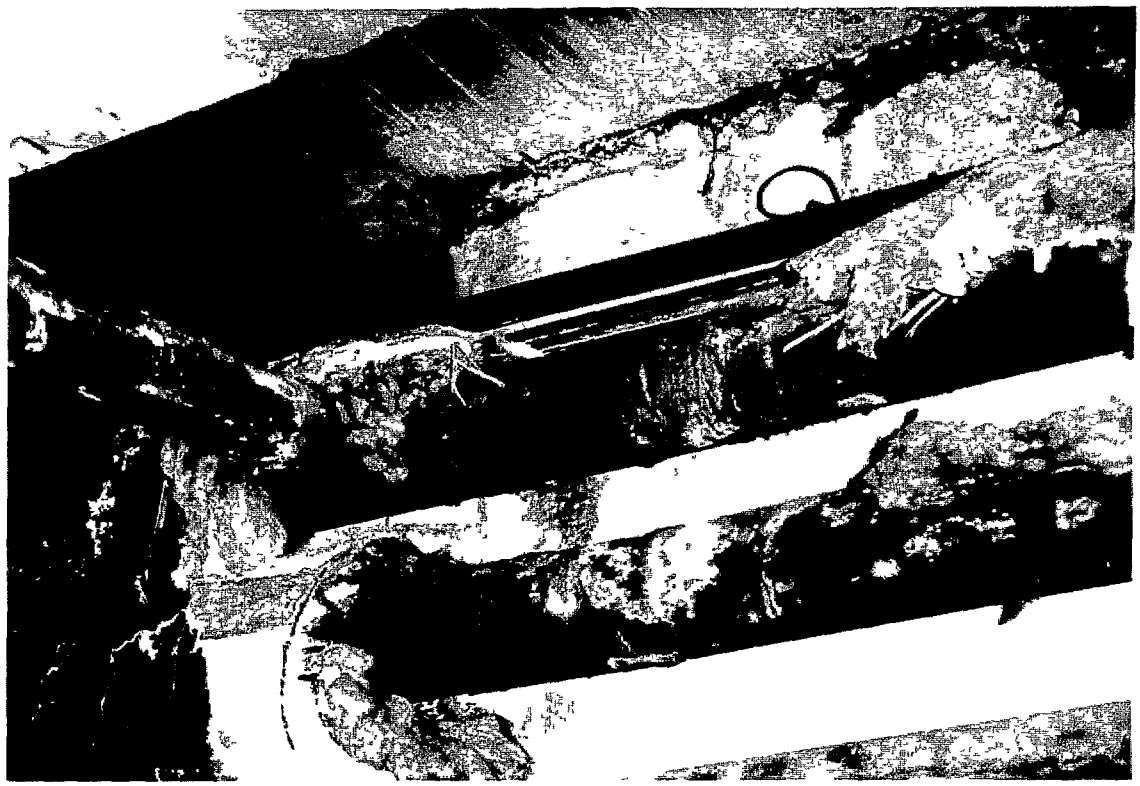
3. Boiler Front Including Burners



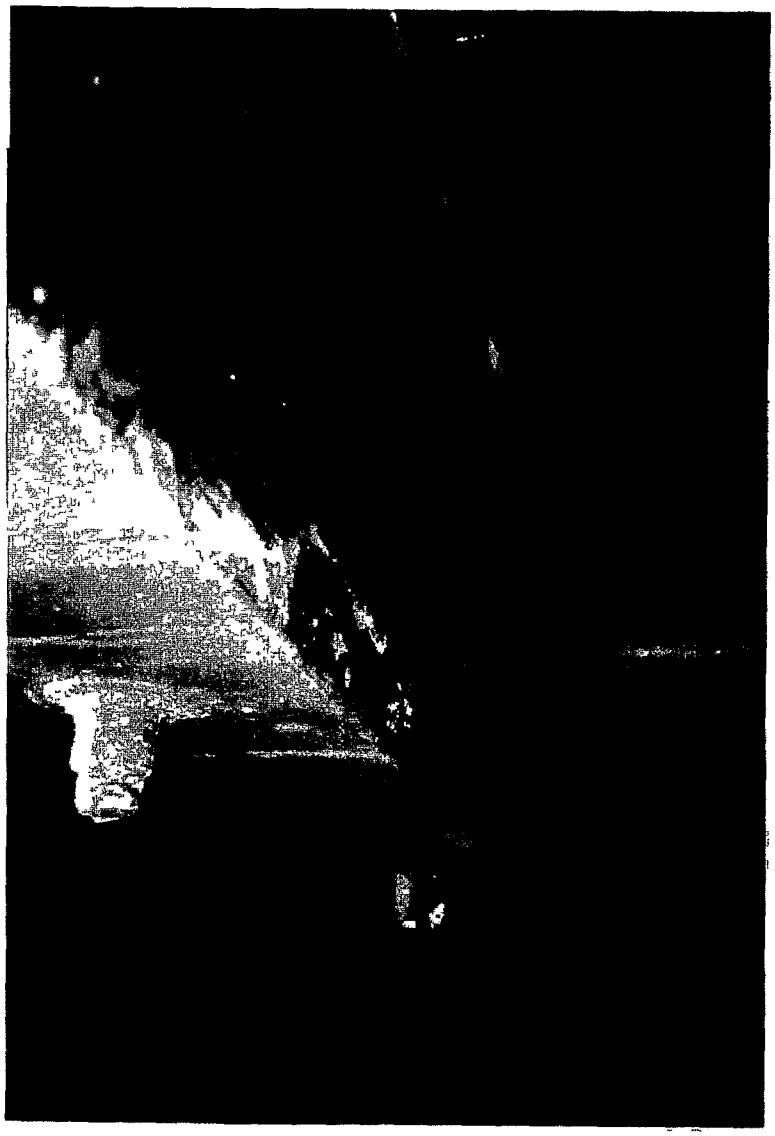
4 Boiler Instrument Panel

5 Installation of Flue Gas Sampling Probe

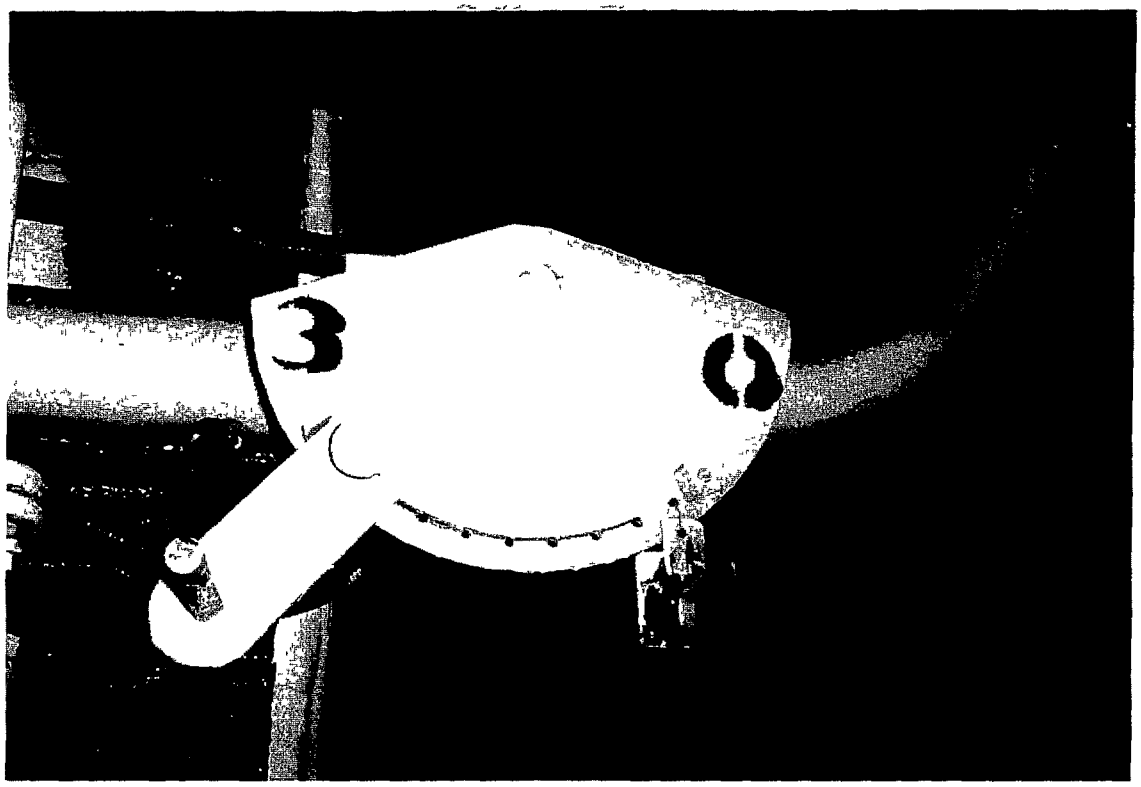
6 Bacharach Combustion Gas Analyzer



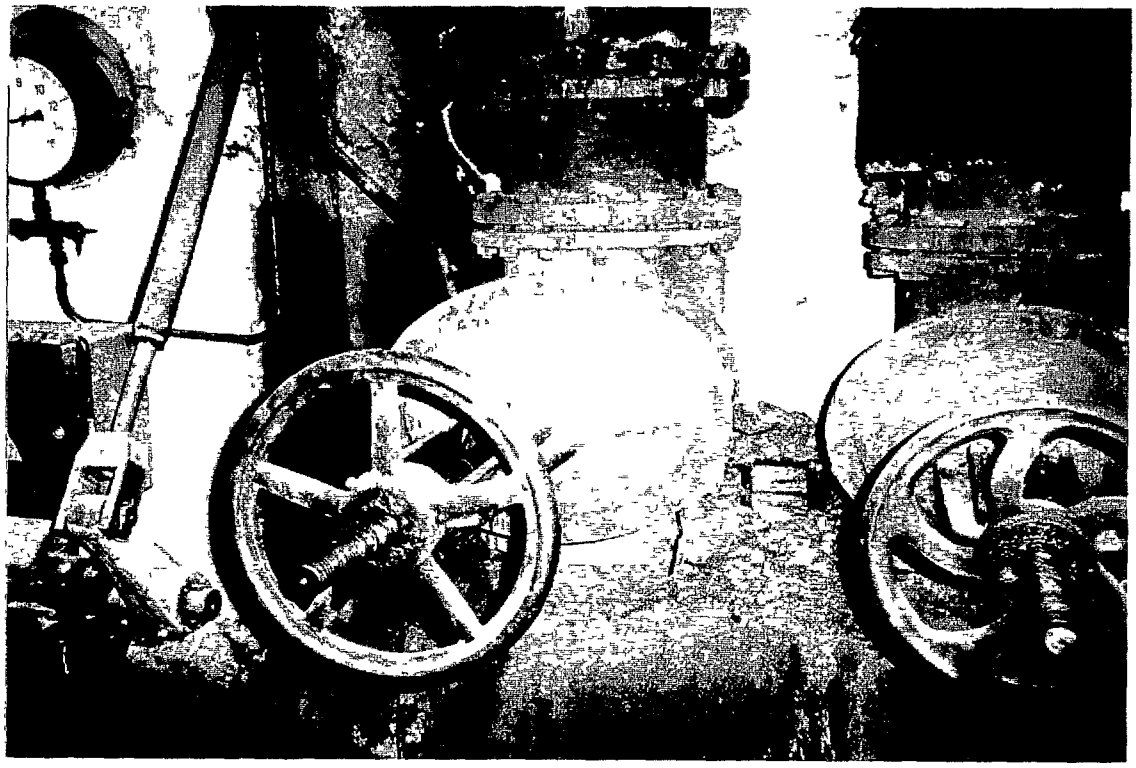
7 BFW Lines,
Missing Insulation



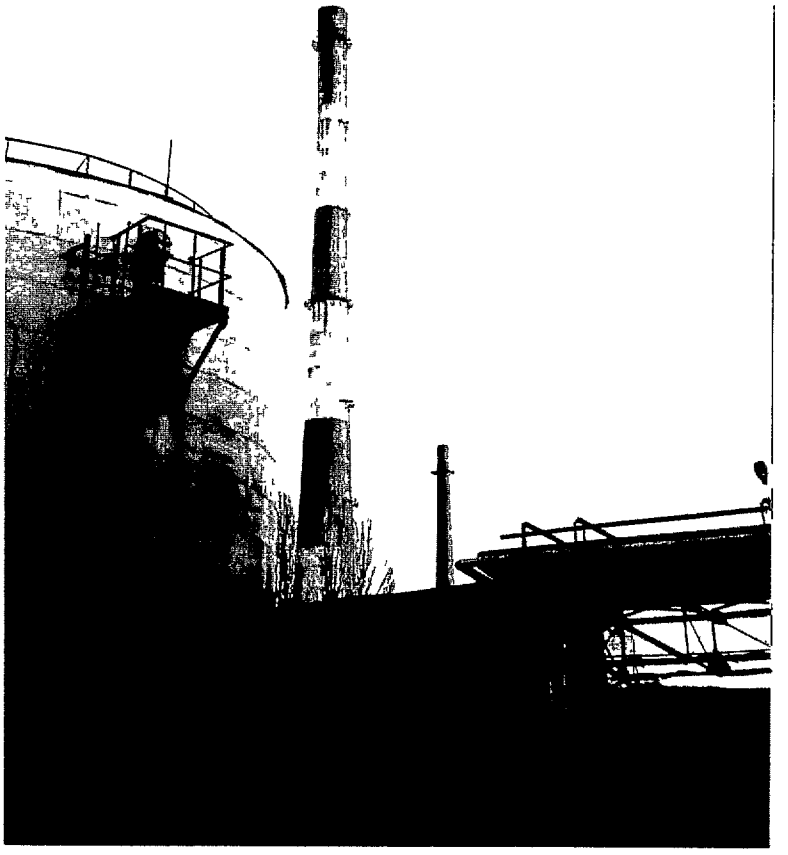
8 Air Distribution
Duct to Boilers



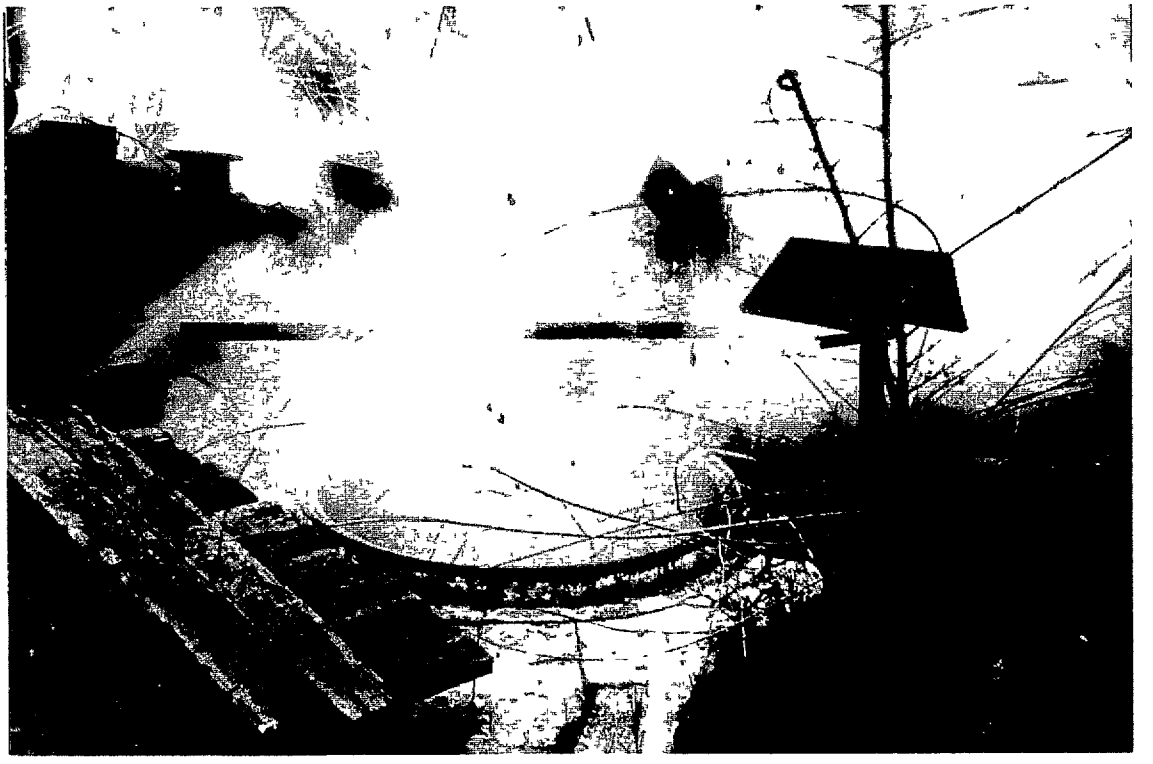
9. Gas Control Valve for Boiler



10 Steam Pressure Reducing Station (8 Bar to 2 5 Bar)

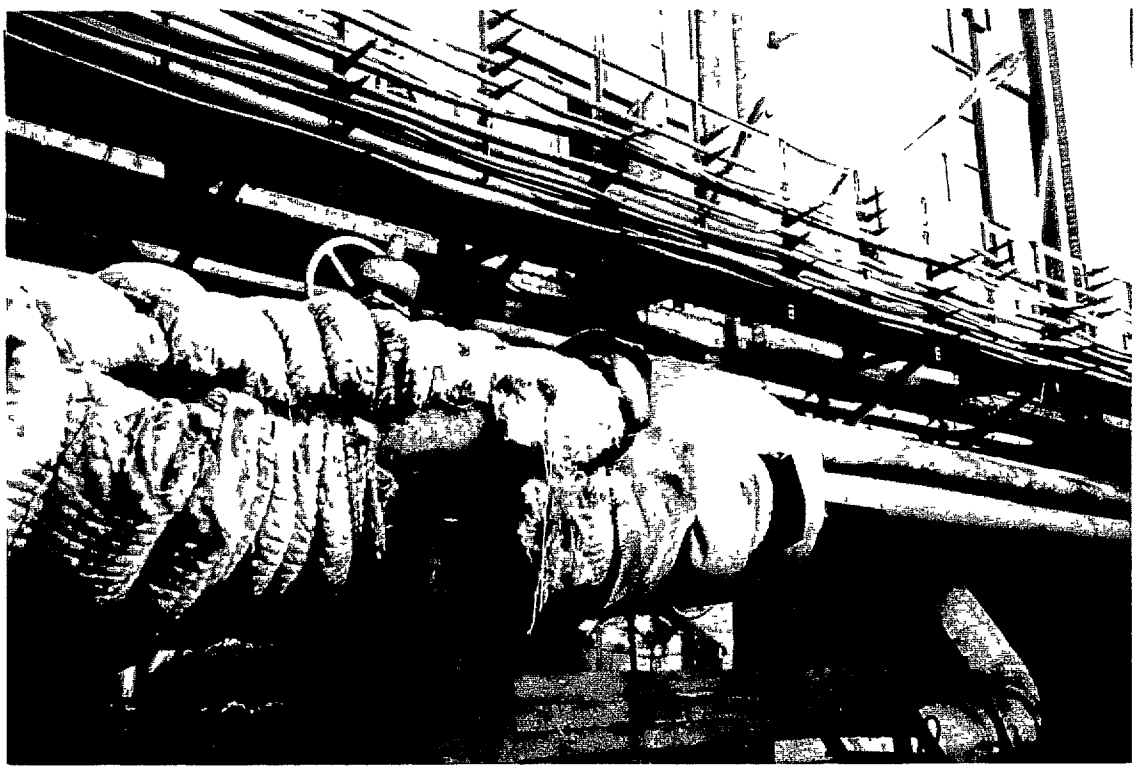


11. Mazut Tank Stacks for Hot Water Heater (Foreground) and Boilers (Background)

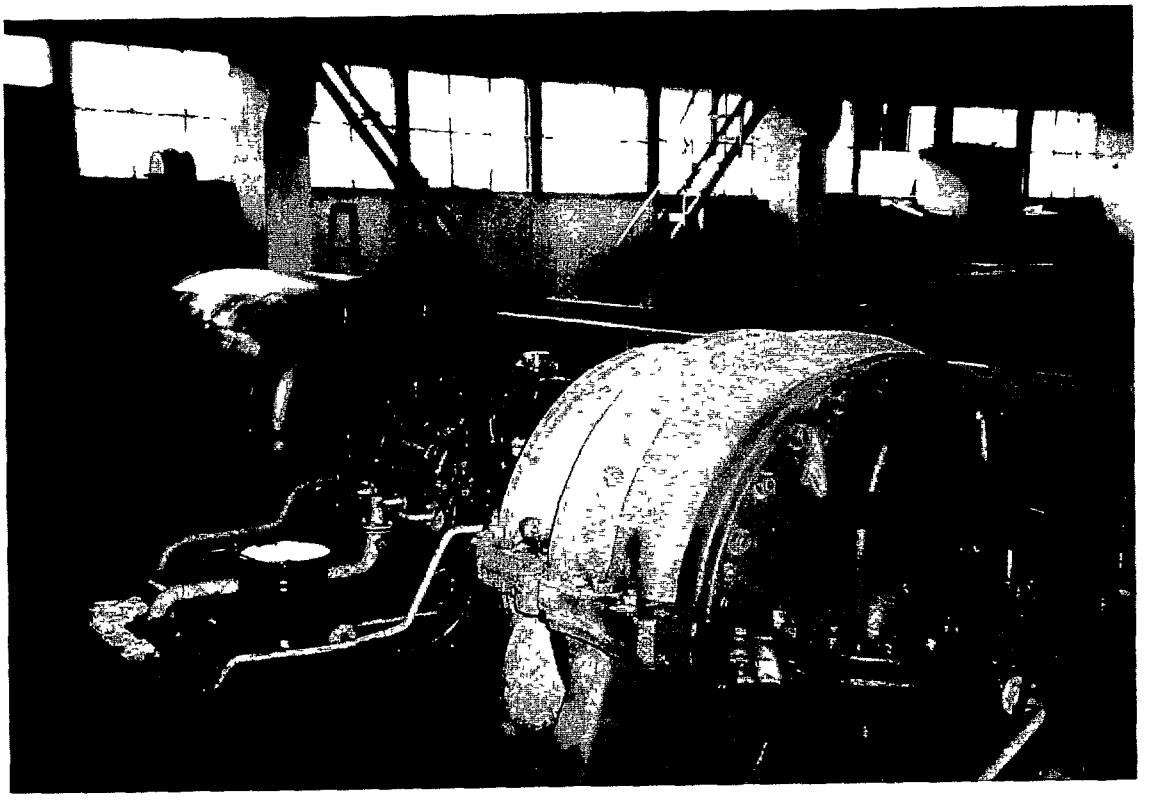


12 Steam Venting from Condensate Tank

13. Insulation Needing Repair



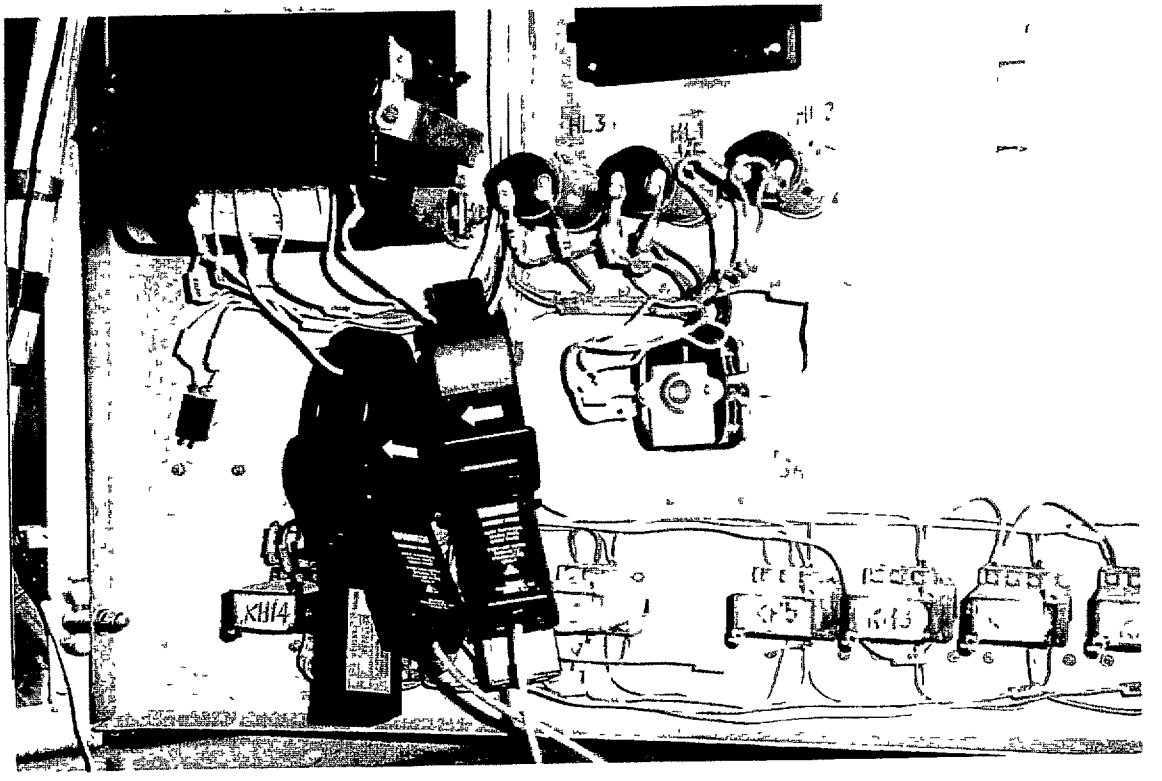
14 Insulation Needing Replacement



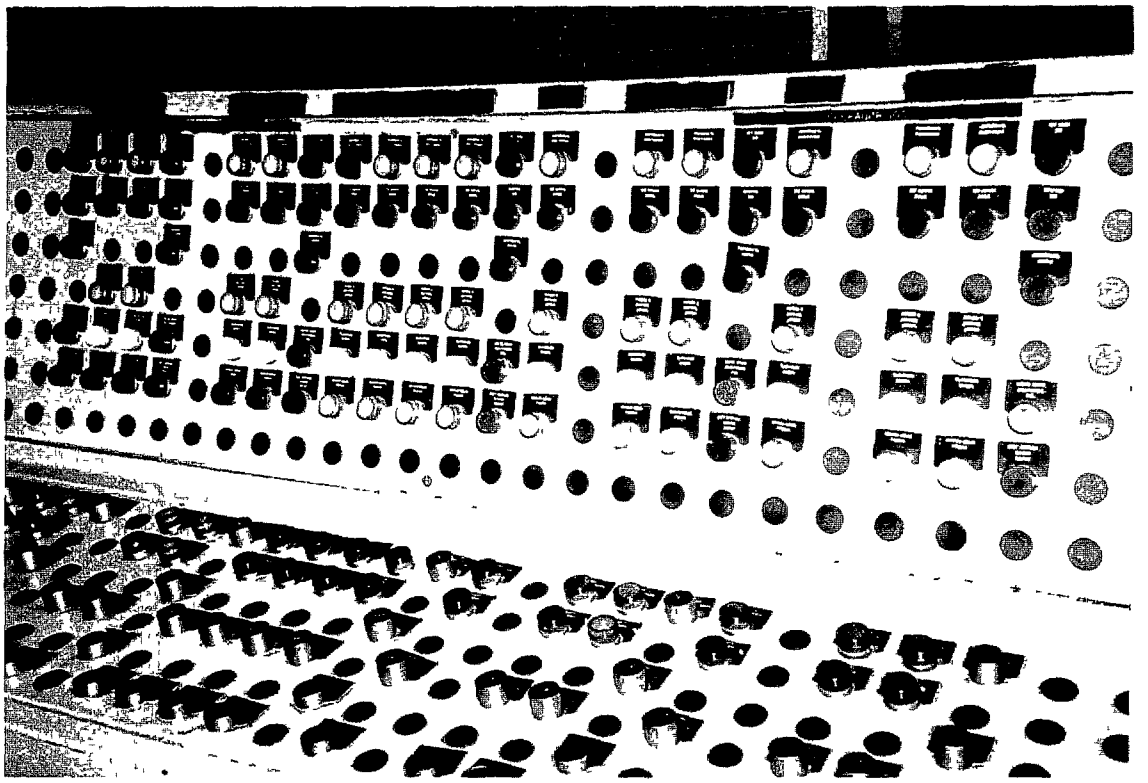
15 Air Compressor (1500 KW)

16 Compressed Air Receivers for Metal Pressing Operation

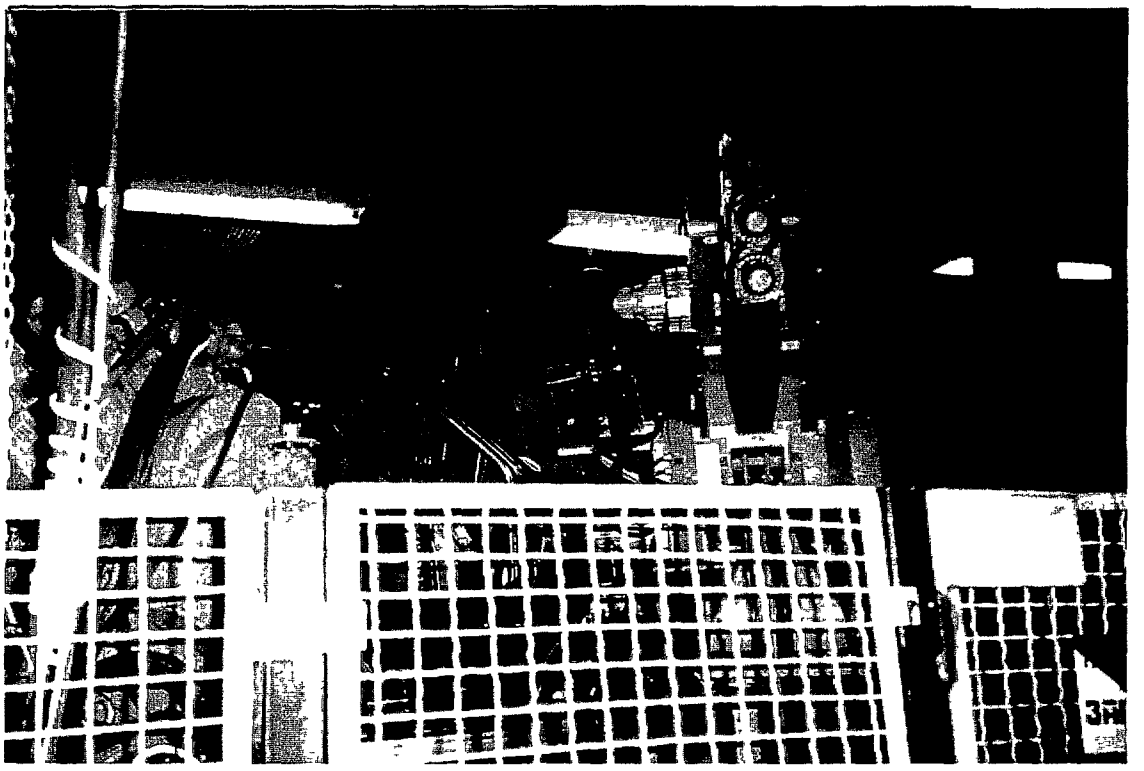
17. Metal Pressing Operation



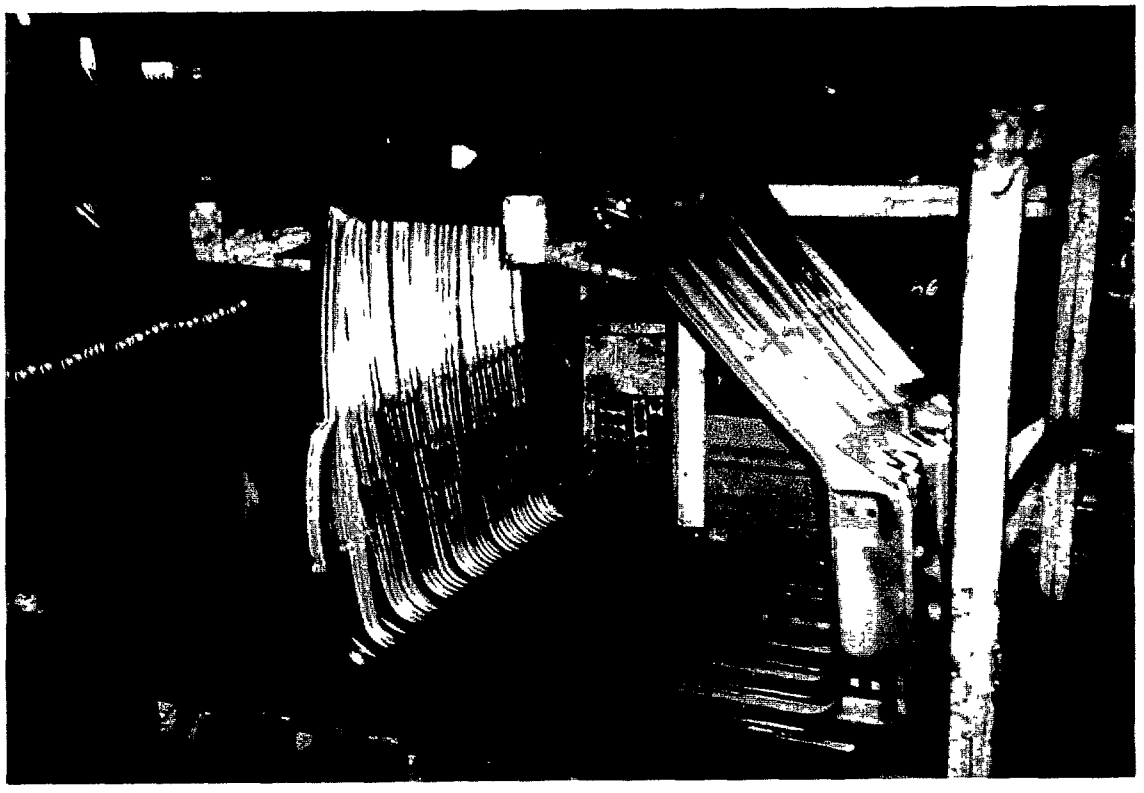
18 Electrical Measurements



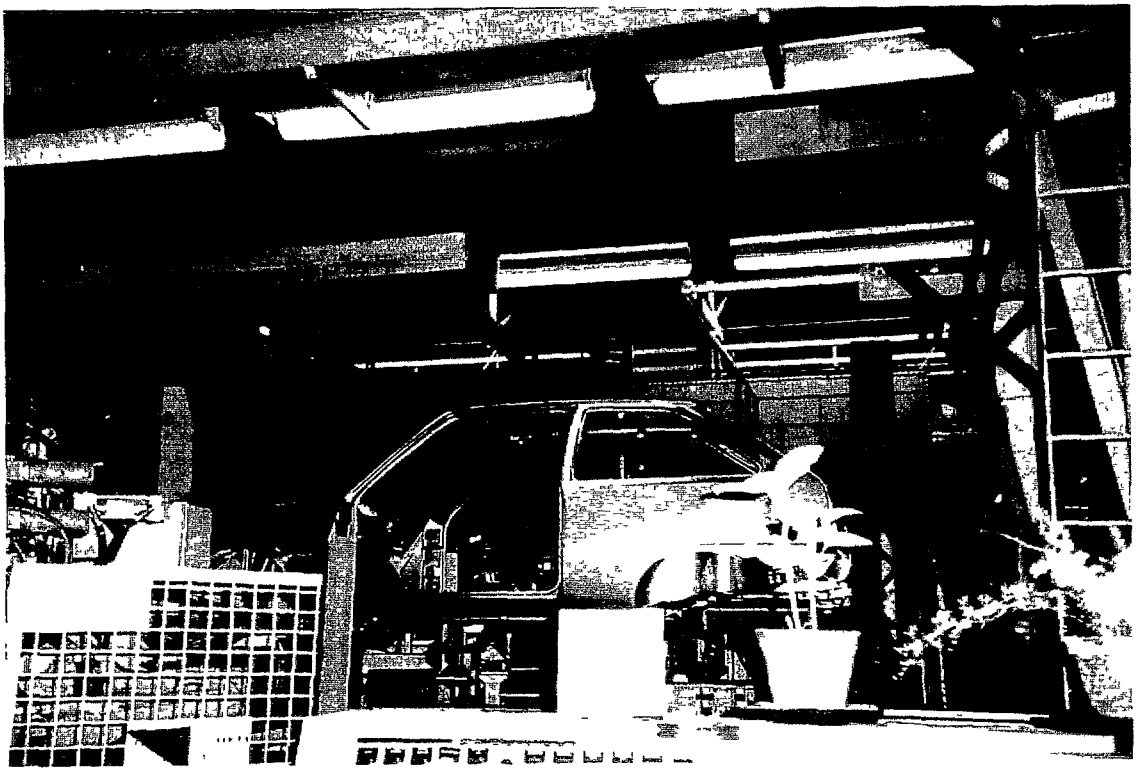
19. Robotics Control Panel



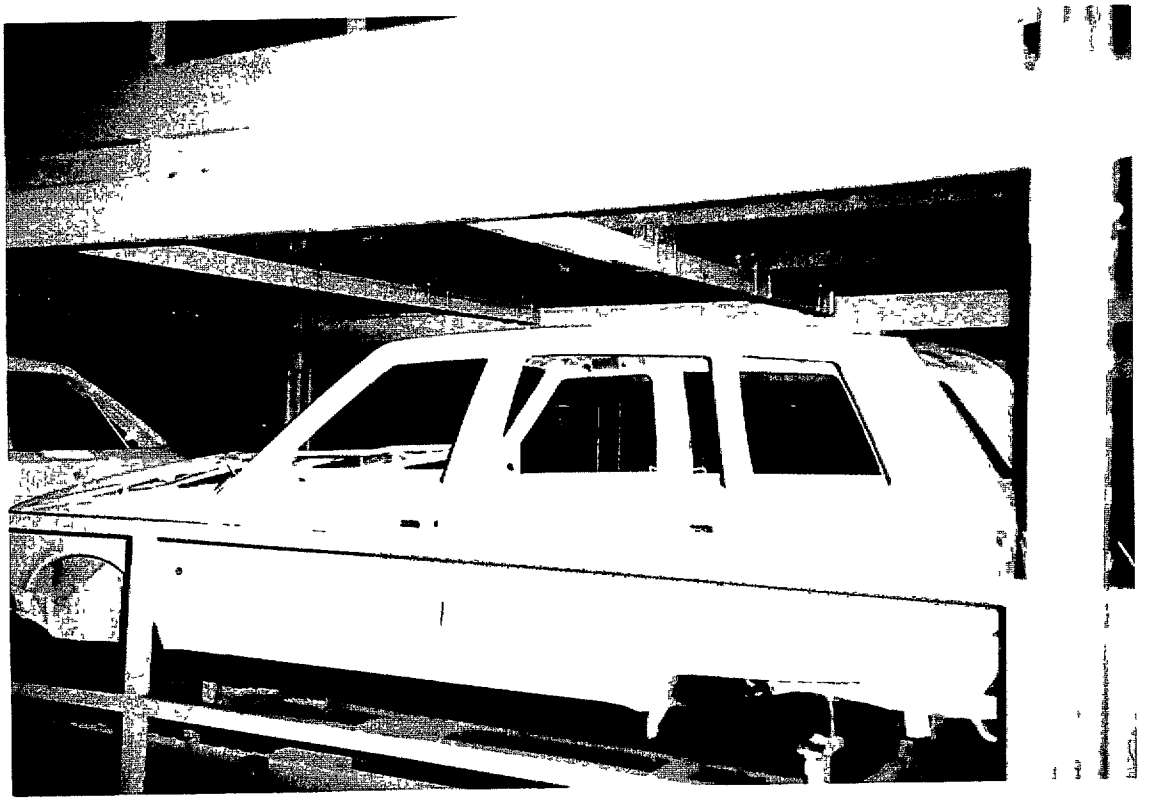
20 Robotic Welding



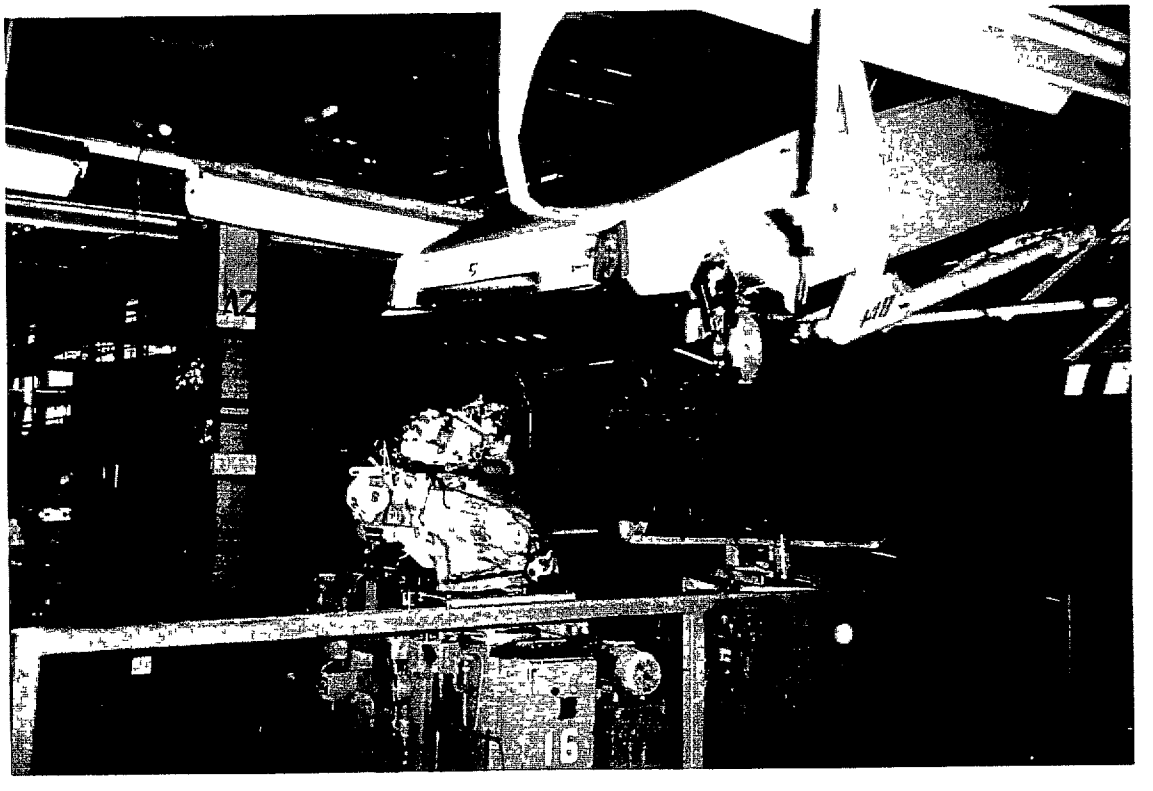
21. Stack of Car Frames



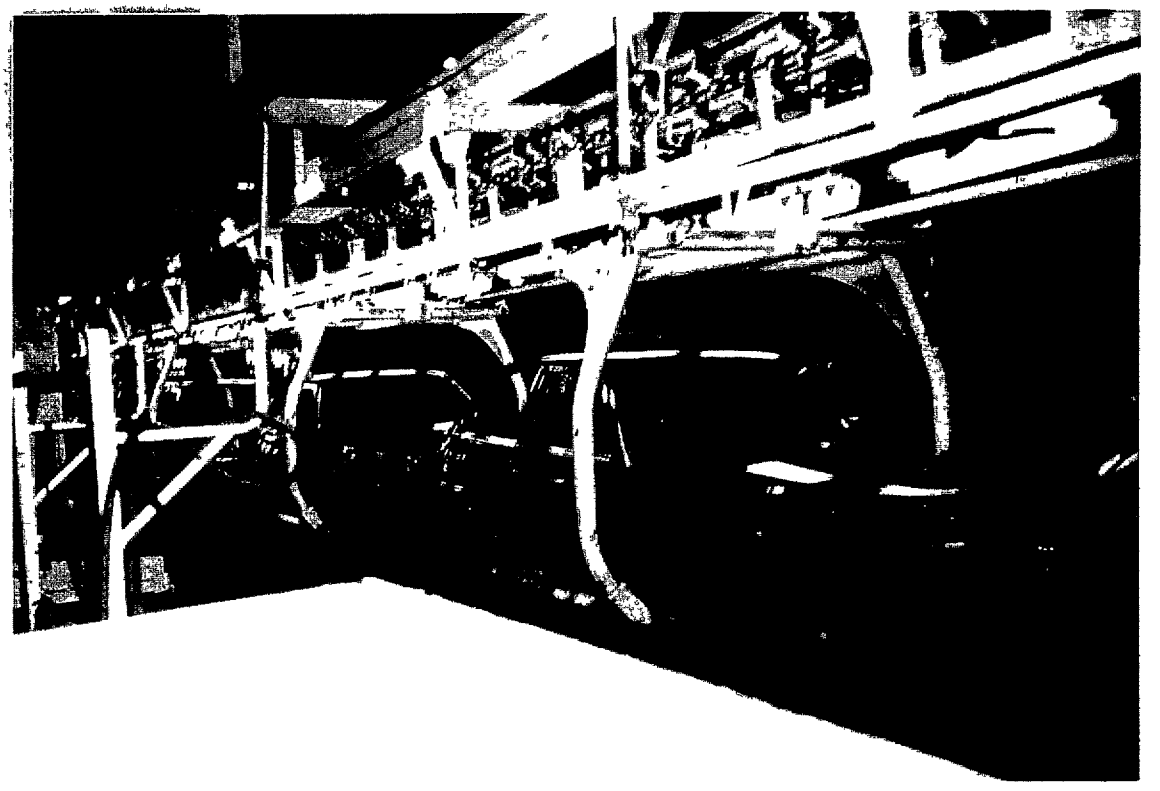
22 Automobile Assembly



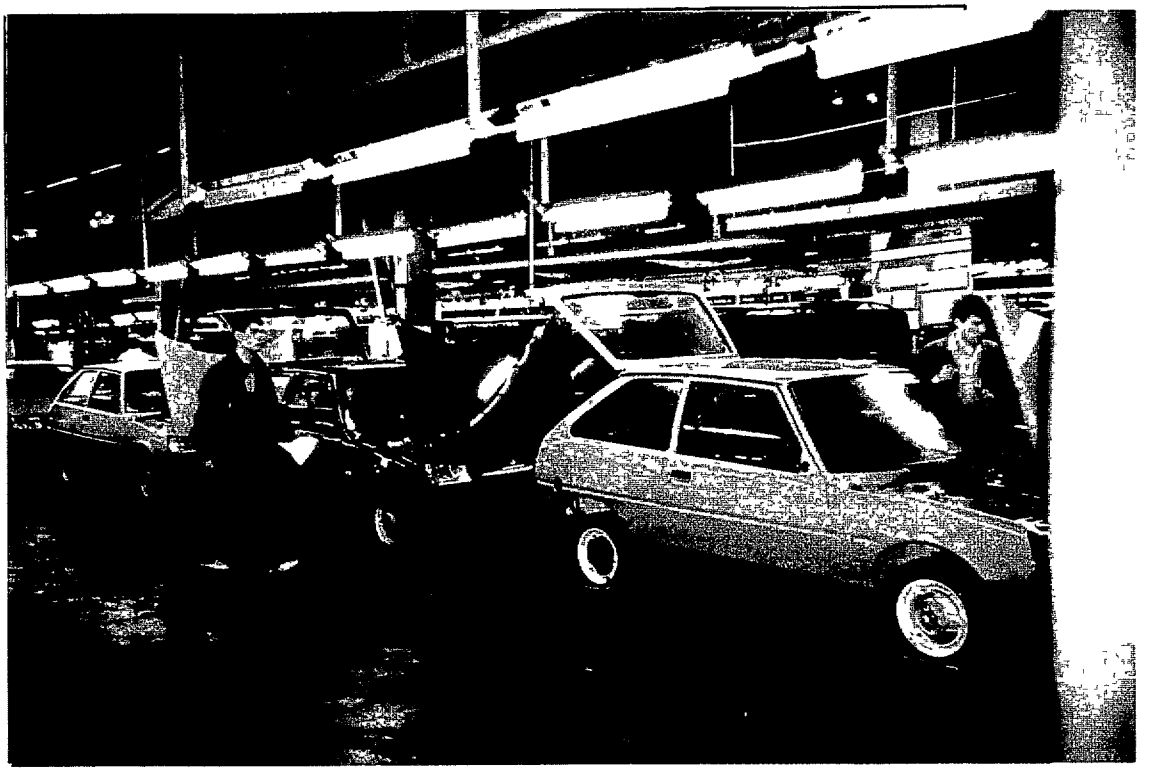
23. Painting Operation



24 Automobile Assembly Engine Installation



25 Automobile Assembly Line



26 Final Assembly Line

APPENDIX "C"

Plant Energy Consumption History

TABLE # "C-1" ELECTRICITY CONSUMPTION

Year 1994	Electricity Consumption in kWh	Electrical Demand in kW	Electrical Reactive in rkVAh
	USAGE	USAGE	USAGE
January	16706869	52000	10695760
February	18197238	52000	11893400
March	18183868	52000	11822440
April	17099664	49000	11012240
May	16522747	49000	111937320
June	18570800	49000	12432920
July	17307234	48000	11332400
August	15543802	48000	10308080
September	15545355	48000	9996360
October	16116380	49000	10287040
November	16358372	49000	9804760
December	17231135	49000	10417760
Annual Totals	203,383,464	-	131,200,480

TABLE # "C-2" NATURAL GAS/OTHER FUEL CONSUMPTION/ AUTOMOTIVE PRODUCTION

Year 1994	Natural Gas Consumption in thousands of cubic meters	Mazut Consumption in metric tons (back-up on boilers)	Automotive Production
	USAGE	USAGE	MONTHLY TOTAL
January	5490	84	7287
February	5230	50	8210
March	4000	29	7824
April	3445	42	9298
May	2351	-	11952
June	2380	-	9826
July	2060	-	7164
August	1975	-	6082
September	1920	-	5735
October	3330	-	5675
November	4986	23	6100
December	5300	364	6209
Annual Costs	42,467	592	91,362

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APPENDIX "D"

World and Local Energy Prices

LOCAL ENERGY PRICES

Note: One Dollar Currently Equals 148,000 Ukrainian Coupons.

Electricity Consumption in kWH Cost in US $	Electrical Demand in kW Cost in US $	Electrical Reactive in rkVAh Cost in US $
0.0155	1.81	0.0019

Natural Gas Consumption in 1,000 Cubic Meters Cost in US $	Mazut/#5 Consumption in Metric Tons Cost in US $
63.00	43.92

	1994 Electrical Costs in Ukrainian Coupons	
Month	Cost of 1 Kwh	Cost of 1 KW Demanded
January	190	23,100
February	320	30,000
March	320	30,000
April	320	30,000
May	320	30,000
June	320	30,000
July	320	30,000
August	320	30,000
September/October	440	50,000
November	1,000	125,000
December	1,700	200,000

LOCAL ENERGY PRICES

Note: One Dollar Currently Equals 148,000 Ukrainian Coupons.

	1995 Electrical Costs in Ukrainian Coupons	
	Cost of 1 Kwh	**Cost of 1 KW Demanded**
January	2,400	282,000
February	2,400	282,000
March	2,300	267,300

PROPOSED
by Deputy Minister of Energy and Electrification
O M Sheberstov

APPROVED
by Deputy Ministry of Economics
V M Kalnik

TARIFFS

on Electricity Generated by Energy Enterprises under the Ministry of Energy of Ukraine

Valid from August 25, 1994

Energy Enterprises	Two -part tariffs		One-part tariffs, karb/kW h					
	Demand charge per 1 kW karb per month	Charge for 1 kW h of consumed electricity Karb	Industry or treated similarly consumers of the current up to 750 kVA Group 2	Food-processing industry Group 4	Electrified rail road transportation Group 5	Electrified local transportation Group 6	Non-industrial consumers Group 7	State establishments
1 VinitskEnergo	240,000	1500	2000	1300	1800	1800	1800	1200
2 DneprEnergo	125,000	1000	1300	1200	1800	1800	1800	1100
3 DonbassEnergo	125,000	900	1300	1200	1800	1800	1800	1100
4 KievEnergo	150,000	1400	1800	1400	1800	1800	1800	1300
5 CrimeaEnergo	240,000	1900	2200	1400	1800	1800	1800	1300
6 LvivEnergo	240,000	1400	1800	1400	1800	1800	1800	1300
7 OdessaEnergo	240,000	1400	1900	1300	1800	1800	1800	1200
8 KharkivEnergo	125,000*	1200*	1500*	1300*	1800*	1800*	1800*	1200

*The ecological supercharge of 5 % have to be added to these tariffs

Notes 1 The existing rules on settling of energy purchases are valid

2 The tariffs for electricity consumed by the district heating system, and domestic hot water system are
750 karb/kW h -- during the time of low night consumption
3490 karb/kW h -- during any other hours

3 The limits for monthly electricity consumption by consumers are canceled

Director of the department of prices
on the production of enterprises of energy, chemical,
metallurgical, and construction materials industry

O I Gridasov

101

STRUCTURE OF THE ELECTRICITY CONSUMPTION
IN THE CITY OF KIEV PER SEPTEMBER 1994

	Millions kW h	%	
Gross Consumption	477 5	100	
Losses	91 7	19 2	
Net Consumption	385 8	80 8	
including			
1 Industry, total	129 4	27 1 (from gross), 33 5 (from net)	
out of it			
"Controlled"	116 6	24 4	30.2
Motorcycle Plant	1 8		
Machine Construction Plant	1 8		
Industrial Enterprise "Bolshevik"	1 5		
Plant "Traktordetal" (Tractor's Part)	6 3		
Industrial Enterprise "Khimvolokno" (Chemical Fiber)	10 4		
Industrial Enterprise named after Korolev	0 6		
Chemical and Pharmacy Enterprise	0 6		
Engineering Machine Plant	0 5		
"Non-controlled"	12 6	2.6	3.3
2 Construction	9 5	2.0	2.5
3 Non-Industrial Consumers	146 4	30 7	37 9
out of it			
Service Sector	104 9		
Transportation	36 9		
State Establishments, Military Units, Universities	10 6		
4 Population	100 5	21 0	26 1

PROPOSED by
Deputy Minister of Energy
and Electrification
O M Sheberstov

APPROVED by
Deputy Ministry of
Economics
V M Kalnik

TARIFFS
on Thermal Energy Generated by
Energy Enterprise of Ministry of Energy of Ukraine

Valid from August 25, 1994
Karbovants per Gcal

Energy Enterprises	Industrial or considering Equal to Industry Sectors (not shown into the other Groups) Group 1	Residential Enterprises, small industrial and commercial enterprises Group 2	Greenhouses, hotbeds, Agriculture Group 3
1 VinitskEnergo	639,800	95,000	397,500
2 DneprEnergo	1,433,200	95,000	556,500
3 DonbassEnergo	678,000	95,000	397,500
4 KievEnergo	1,123,900	95,000	556,500
5. CrimeaEnergo	1,552,500	95,000	556,500
6. LvivEnergo	510,200	95,000	420,000
7. OdessaEnergo	1,643,400	95,000	556,500
8 KharkivEnergo	1,274,100	95,000	397,500

Notes 1 The existing rules on settling of energy purchases are valid
2. Value added taxes are not included in these tariffs
3 The tariffs introduced from March 1, 1994 are canceled with the introduction of new ones

Director of the department
of prices on the production of enterprises
of energy, chemical, metallurgical, and
construction materials industry

O I Gridasov

June 2, 1994

ENERGY PRICE UPDATE

End-use energy prices for OECD Europe

Source OECD, third quater 1993, IEA Statistics, Energy Prices and Taxes

	units		year of price estimate
Gasoline	$US/liter	0 988	1992
	$US/toe	1220 5	1992
Diesel Fuel	$US/liter	0 623	1992
	$US/toe	712	1992
Light Fuel Oil for industry	$US/1000 liter	312 46	1992
	$US/toe	363 2	1992
Light Fuel Oil for households	$US/1000 liter	401 27	1992
	$US/toe	468 3	1992
Heavy Fuel Oil for industry	$US/1000 liter	151 08	1992
	$US/toe	156 5	1992
Electricity for industry	$US/kWh	0 076	1991
	$US/toe	887	1991
Electricity for households	$US/kWh	0 138	1991
	$US/toe	1607 7	1991

	units		year of price estimate
Heavy Fuel Oil for utilities	$US/1000 liter	137 43	1991
	$US/toe	143 2	1991
Natural gas for industry	$US/10^7 kcal	170 54	1991
	$US/toe	189 5	1991
Natural gas for utilities	$US/10^7 kcal	145 48	1991
	$US/toe	161 6	1991
Natural gas for households	$US/10^7 kcal	490 7	1992
	$US/toe	545 2	1992
Steam Coal for industry	$US/tonne	103 41	1991
	$US/toe	154 3	1991
Steam Coal for utilities	$US/tonne	80 2	1991
	$US/toe	137 3	1991

APPENDIX "E"

List of Contacts Made in Facility

CONTACTS MADE DURING SITE AUDIT

COMPANY NAME & PLANT ADDRESS
Kommunar/ZAZ Car Plant
8, Lenin Av.
Zaporozhye 330600

ZAPOROZHYE TELEPHONE COUNTRY AND CITY CODE (7 0612)

PLANT TELEPHONE - 643689 **PLANT FAX** - 645453

Konstantin Markovich Krakhmal
Chief Power Manager
Tel. - 643952

Victor Fedorovich Kozhanov
Boiler Chief

Eduard Anatolievich Tronichev
Foreign Trade Firm Department Head

Ivan Lukich Vinnik
Workshop Chief

Valentin Fedorovich Diadechko
Deputy Chief Power Manager

Viacheslav Georgievich Tkachuk
Heat Network Master

Iosif Naftulovich Dergoer
Deputy Chief Power Manager for Electricity

Sergey Sergeevich Arkhipov
Senior Boiler Master

Victor Ivanovich Gishtymult
Head of Design Bureau for
the Power Management

March 10, 1995

APPENDIX "F"

Abbreviations and Units Conversions

AC	=	alternating current
amps	=	amperes
atm	=	atmosphere = 14.696 pounds per square inch
bar	=	100,000 pascals = 14.504 pounds per square inch
BTU	=	British thermal unit
cfm	=	cubic feet per minute
cm	=	centimeter = 0.3937 inches
cm^2	=	square centimeter = 0.155 square inches
CO	=	carbon monoxide
CO_2	=	carbon dioxide
DC	=	direct current
°C	=	degree Celsius T[°C] =(5/9)x(T[°F] - 32)
°F	=	degree Fahrenheit
°R	=	degrees Rankine T[°R] = T[°F] + 460
ECO	=	Energy Conservation Opportunity
eff	=	efficiency
ex air	=	excess air
ft^2	=	square feet
ft^3	=	cubic feet
Gcal	=	gigacalorie = 1 billion calories = 3.968 million BTU
GJ	=	gigajoules = 1 billion joules
gph	=	U.S. gallons per hour
gpm	=	U.S. gallons per minute
GWh	=	gigawatt hours = 1 billion watt hours
H_2	=	hydrogen
H_2O	=	water
H_2SO_4	=	sulfuric acid
hectare	=	10,000 square meters = 2.471 acres
hectoliter	=	100 liters = 26.42 U.S. gallons
Hg	=	mercury
hr	=	hour
Hz	=	hertz = cycles per second
J	=	joules
kcal	=	kilocalories = 1 thousand calories = 3.968 BTU
kg	=	kilogram - 2.2046 pounds
Kg_f	=	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
kPa	=	kilo pascals = 1 thousand pascals = 0.14504 pounds per square inch
kV	=	kilovolts = 1 thousand volts

kVA	=	kilovolt-amperes
kVAr	=	kilovars = 1 thousand volt-amperes (reactive)
kW	=	kilowatt = 1 thousand watts
kWh	=	kilowatt = 1 thousand watt hours
lbs	=	pounds
liter	=	0.2642 U.S. gallons = 0.03531 cubic feet
m	=	meter = 39.37 inches
m^2	=	square meter = 10.76 square feet
m^3	=	cubic meter = 35.31 cubic feet
mA	=	milliampere = 0.001 amperes
MCal	=	megacalorie = 1 million calories
metric ton	=	1 thousand kilograms = 1.1023 U.S. tons
mg	=	milligrams
min	=	minute
MJ	=	megajoules
MM	=	million
mm	=	millimeter = 0.03937 inches
MPa	=	1 million pascals = 145.04 pounds per square inch
MVA	=	megavolt-amperes
MW	=	megawatt = 1 million watts
MWh	=	megawatt hours = 1 million watt hours
NG	=	natural gas
nm	=	nanometer
Nm^3	=	cubic meters at standard conditions of temperature and pressure (20°C and 1 atmosphere)
NO_x	=	nitrogen oxide
O_2	=	oxygen
P	=	pressure
PC	=	personal computer
ppm	=	parts per million
psi	=	pounds per square inch
psig	=	pounds per square inch (gauge)
R	=	ruble
s	=	second
SO_2	=	sulfur dioxide
sq ft	=	square feet
Tcal	=	teracalorie = 1 trillion calories = 3.968 billion Btu
T	=	temperature
TPS	=	Thermal Power Station

V	=	volts
VA	=	volt-amps
VArs	=	volt-amps (reactive)
VSD	=	variable speed drive
yr	=	year