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Industrial Energy Efficiency - Ukraine
April 1998

REPORT
ON ENERGY AUDIT
AT OPEN JOINT-STOCK COMPANY
"VINNYTSIA TRACTOR AGGREGATES PLANT",
Vinnytsia City, UKRAINE

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1 0 EXECUTIVE SUMMARY

1 1 Introduction

This energy audit has been conducted under a program sponsored by the U S Agency for International Development This project, referred to as Delivery Order #30, consisted of performing twenty four audits throughout Ukraine The purpose of the project was to develop Ukrainian energy service company (ESCO) capabilities To accomplish this task, *Burns and Roe Enterprises, Inc* (the primer contractor) hired Ukrainian engineers These engineers were trained in U S techniques of conducting energy audits and in ESCO concepts The industrial energy audits were conducted to facilitate the ESCO training

This energy audit was performed in accordance with the program financed by the United States Agency for International Development (USAID) according to Delivery Order #30 The given project provides making energy audits at 24 industrial Ukrainian facilities The aim of the project id setting-up independent Ukrainian energy servicing companies (ESCOs) To implement the said task the company *Burns and Roe Enterprises, Inc* (General Contractor) invited Ukrainian engineers These specialists were taught to the methods of making energy audits in the USA and to the principles of organizing operation of ESCOs Making energy audits at industrial facilities contributed to practical preparation of ESCOs

Energy audit making included visiting for a week an enterprise by a group of engineers that usually consisted of two or three people So, one week was not enough for making a complete energy audit at the plant, as mainly large plants were chosen for making energy audits In many cases there occurred a necessity to focus the energy audit works on one processing line or on one plant department Hence, the given audit is based on what we really managed to do for a week Though the audit already includes a whole set of recommendations for the plant management, it is expedient to make a complete integral energy audit of the plant It is desirable that the plant management should invite specialists prepared within the framework of this project to continue the work, which must bring to improvement of the whole situation with energy consumption at the plant and to making the full list of the measures to be used to improve the energy consumption at the plant

1 2 Principal Findings

The basic product of the plant is gear-type hydraulic pumps, hydraulic cylinders and assemblies for the pneumatic brake systems for tractors, agricultural machines, road-building and other machines

The plant has two production grounds - Production Ground #1 in the center of the city and Production Ground #2 - in the industrial zone of the city

The energy audit was performed at the main part of the facility - Production Ground #1 - that manufactures the basic part of the total output

The plant has its own sources of thermal energy, the basic and ancillary subdivisions that provide the complete manufacture cycle

The Open Joint-Stock Company *"VZTA"* is quite a large consumer of natural gas and electric power In 1997 there were spent USD 1 4 million to buy energy sources

While making the audit, the re were found a lot of attractive opportunities for improving the energy efficiency of the enterprise, both by improving the energy efficiency of the production, and at the cost of short-term measures (up to 1 year) that do not require large investments, and by implementing the middle-term measures (up to 2 years) that require large capital investments

Implementation of the proposed measures will ensure to receive the following savings

- saving of electric power by 2,662,000 kW h or 13 %,
- saving of natural gas by 1,3445,000 m^3 or by 16%

The costs on energy resources is USD 342,235 per year, providing that the costs of commissioning and implementation of the proposed measures are USD 39,692

At the same time the amount of emissions of harmful substances into the atmosphere (CO, SO_2, NO_x and ash) decreases by 47 5 tonnes per year

The plant has reserves for further energy saving, implementation of which will require a more detailed energy audit

1 3 Recommendations

The following table shows a list of energy conservation opportunities (ECOs) identified for the facility The table shows the estimated savings as well as the cost savings and the paybacks for each opportunity Four of the seven opportunities listed have paybacks of one year These opportunities are recommended for implementation as soon as possible

To encourage the facility to implement energy efficiency and energy conservation, USAID is contributing energy auditing equipment to the plant This equipment consists of standard energy auditing instrumentation and meters that will enable them to implement an energy saving activity This item is shown in the table as **ECO #1** This recommendation is for the plant to implement an energy management section that would be responsible for recommending changes or improvements in any system that would result in energy savings

Typically, an energy management team or section would consist of the minimum of three persons, an engineering supervisor, an electric engineer and a thermal engineer The supervisor would be a part of the upper plant management, and should report directly to the plant management This is so that energy usage and energy are elevated in importance, and that the plant manager is aware of potential changes to save energy

The main directions concerning the energy conservation at the plant that are recommended after gaining the energy audit data as follows

- organization of an automatized system for metering at the plant consumption of energy resources, which will allow to introduce at the plant a system for controlling and checking energy costs **(ECO #2)**,
- improvement of the efficiency of gas combustion in the boiler-house **(ECO #3)**,
- repair leaks of compressed air **(ECO #4)**,
- replacement of the lamps for lighting the production rooms in Workshop #5 **(ECO #5)**,
- infra-red gas-fired heating systems **(ECO #6)**,
- steam electric power generating plant **(ECO #7)**,
- transfer of the melting furnaces of *NO*-136 type on natural gas **(ECO #8)**

The measures with a short payback term (ECOs #1, 2, 3, 4) are recommended for the primary implementation When financial opportunities improve at the plant, the plant management should consider the issue of implementation of *the other measures (ECOs # 5, 6, 7 and 8)*

1 4 Operation and Energy Management

It is typical for industrial plant management to mainly think in terms of production, and to want to increase its output Therefore it is sometimes difficult to think of the importance of energy and energy costs on the operation of the plant

For JSC *"VZTA"*, as with most industries in Ukraine, in the past the energy costs were significantly subsidized, therefore energy saving was not a major consideration in the plant operations

With the rising energy costs during the past few years, the energy costs have now become very influential part of the expenses The energy costs at *Vinnytsia Tractor Aggregates Plant* are about 19 per cent of the total cost of the products produced

Currently, at JSC *"VZTA"*, like at other Ukrainian enterprises too, though the problems in relation of the energy resources and energy costs are now well understood by the staff, there is a tendency to think of implementing large projects with the intent of saving large amounts of energy And at the same time at the facilities a large number of small energy saving projects exist that have short payback periods

Most industries in Ukraine have a person or persons who are referred to as energy engineers These people are typically responsible for ensuring that there is an adequate supply of energy to the plant, not to improve the energy efficiency of the plant But with the rise in energy prices and the uncertainty of availability of all fuels, an energy manager to conserve energy becomes important Each plant should seriously consider establishing an energy manager position as a minimum, and for large industries, possibly even an energy management section

These people should be regularly monitoring all operations, and especially reviewing monthly energy consumption This monthly data should be graphed and compared to previous months and years to determine any variations in consumption Where variations do occur, they should then determine the cause of the variation and if remedial action is required For instance, if monthly consumption increases, the reasons why should be determined and if appropriate, steps taken to correct any problem

In addition, the energy management staff should also review each process, and look for energy saving opportunities They should see that all cost effective energy improvements are implemented, beginning with items identified in this energy audit They should then also have responsibility to review all proposed changes to the facility to ensure that each process is as energy efficient as possible

A plant the size of JSC *"VZTA"* should have several people working in an energy management group As a minimum, it would be good to have a thermal specialist (someone who is knowledgeable about steam and gas supply systems) and a specialist in the electrical power engineering There should be a third person to manage all of the activities of this group, and to report directly to the top plant management

At many facilities the energy management section is assigned an energy goal, such as "reducing the overall energy usage by five percent per year" While the percentage goal can vary, this type of challenge gives a benchmark by which the section can be evaluated And in industries in Ukraine, where energy efficiency is just at its infancy, the percentage goal could even be higher Some industries also have an incentive program, in which employees are encouraged to submit energy efficiency improvement ideas These ideas, if accepted and implemented, would result in a small reward being given to the employee

Table 1
Energy Conservation Opportunities (ECOs)

ECO	Description	Energy Savings			Energy cost savings, USD	Project costs, USD	Payback period, year(s)
		Electric power, (x 1,000 kW h)	Natural gas, (x 1,000 m³)	Steam, Gcal			
1	Implementation of an energy management program	1,019 5	414		73,900	62,950	0 8
2	Automatic systems for metering the energy resources consumption	612	827		90,640	93,000	1 03
3	Optimization of gas burning in steam boilers		95 6		7,648	7,000	0 9
4	Repair leaks of compressed air	56 2			2,247	2,000	0 89
5	Replacement of lamps for lighting the production rooms in Workshop #5	99			3,960	3,962	1 0
6	Infra-red gas-fired heating systems		8	720	11,440	19,030	1 7
7	Steam electric power generating plant	875			35,000	68,500	1 96
8	Transfer of the melting furnaces on natural gas				117,400	140,250	1 4
	Total	**2661 7**	**1344 6**	**720**	**342,235**	**396,692**	

2 0 GENERAL BACKGROUND

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2 1 History of Plant

The plant was set up in 1880 (*"MOLOT"* Plant for Pig Iron Casting) After its unification with a machine and tractor workshop in 1933 it was named *Vinnytsia Plant for Automobile and Tractor Repairing named after Gorky*, and in 1956 it was named *Vinnytsia Plant for Aggregates* Since 1970 the Plant has had its current name

During World War II the plant was destroyed completely, and it had been completely restored by the end of 1948 In the 1970's the reconstruction of the plant was fulfilled, it was aimed at improvement of the production efficiency

The main product of the plant is gear-type hydraulic pumps, hydraulic cylinders and assemblies for pneumatic brake system in tractors, agriculture machines, machines for road works and other kinds of machines

At the end of the 1980's the plant co-operated with 80 large suppliers of raw and other materials, as well as with more than 600 customers Its products were exported to 50 countries

In 1997 the enterprise was reorganized into the Open Joint-Stock Company *"Vinnytsia Tractor Aggregates Plant"* Currently the shares are being sold The State Property Fund of Ukraine approved in 1997 a plan of selling the shares of the enterprise

The enterprise has all facilities for manufacture of hydraulic pneumatic drives, such as follows

- mechanical and assembling facilities,
- casting facilities (pig iron and color metals casting),
- pressing and thermal processing facilities,
- facilities for electric plating,
- repair and maintenance services,
- other facilities

A peculiar feature about the plant is the availability of two separate production grounds (an "old" production area #1, and a "new" Production Ground #2) that are at a distance of 4 kilometres from each other

The structure of the enterprise (Production Ground #11) includes 7 basic workshops, 5 separate areas, a boiler-house, a water circulation station and the plant administration

2 Types of products

Currently *'VZTA"* is the largest Ukrainian enterprise manufacturing the following kinds of products

- gear-type hydraulic pumps - 9 designs
- gear-type hydraulic monitor - 1 type
- hydraulic cylinders - 13 designs
- hydraulic hoses - 7 designs
- valves - 4 designs
- assemblies for the pneumatic brake systems for tractors and tractor trailers - 11 items
- spare parts for automobiles - 13 items
- consumer goods - 12 items

2 3 Number of employees

On March 25, 1998 the average number of the employees at the plant was 2,347 persons

2 4 Significance of the sector to economy

As the Open Joint-Stock Company *"Vinnytsia Tractor Aggregates Plant"* is one of the largest in Ukraine and in NIS manufacturers of hydraulic pneumatic equipment for agriculture machines of different purposes, and its products are competitive, this trend in the enterprise activities seems to have prospects in Ukraine

3 0 CURRENT STATUS OF PRODUCTION

3 1 Maximum estimated production capacity of plant

The maximum production capacity of the plant reached in 1989 was 65,564,000 roubles

3 2 Real production capacity of plant

The total production capacity was as follows in 1995 - 15,429,400 hrn , in 1996 - 15,893,000 hrn , in 1997 - 15,701,000 hrn The labor production capacity per one employee in 1997 was 6,480 hrn

Monthly amount of the products for sale manufactured by *VZTA* in 1997 (in thousands of hrivnias)

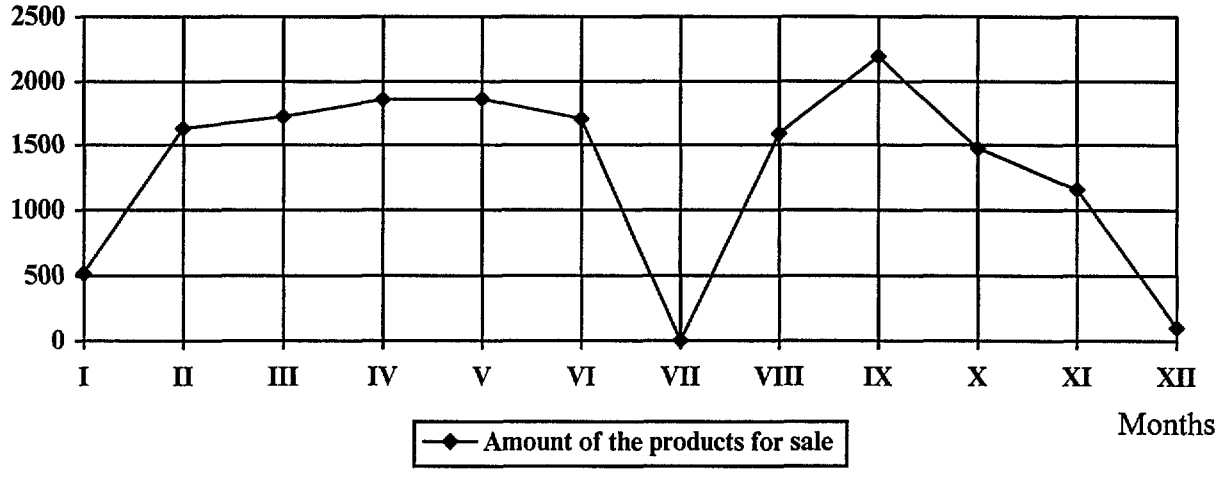

Fig 3 1

Decline in the production level in 1997 in January, July and December are accounted for by the fact that *VZTA* did not operate in that period

3 3 Current Trend

The basic sale market for the hydraulic and pneumatic equipment for agriculture and road machines, besides Ukraine, is Russia and Belarus Currently there is in progress work aimed at renovation of the sale markets

3 4 Export vs Domestic production

Due to the data from the enterprise, in 1997 export of the products was 6,275,000 hrn or 32 8 per cent of the total sale of the products

3 5 Basic energy consuming areas and equipment

3 5 1 Compressed air

Compressed air is used at JSC ' *VZTA* " mainly by the processing equipment in the metal assembling workshops and by the metallurgical equipment in the casting workshop and in the pressing-and-thermal processing workshop (moulds, casting machines, the blowing of parts) In 1997 37,143,000 m^3 of compressed air was produced, its production required 2,818,000 kW h of electric power that cost US $101,467

Analysis of the below plot for electric power consumption by the compressor station on the basis of the data for 25 03 98 showed that the maximum loads for the compressors coincide with the beginning of the working day and with the end of the lunch break for the basic production lines and areas, and it does not change much during the plant operation time After the end of the day shift at the basic production lines and areas the consumption of the power decreases, and at night it is in average 540 kW (85 per cent of the nominal value of the load) - only the casting and muffle-free aggregate continue to operate, the total consumption of compressed air by these is about 27 per cent of the total consumption by the plant It is evidently that significant losses are taking place here

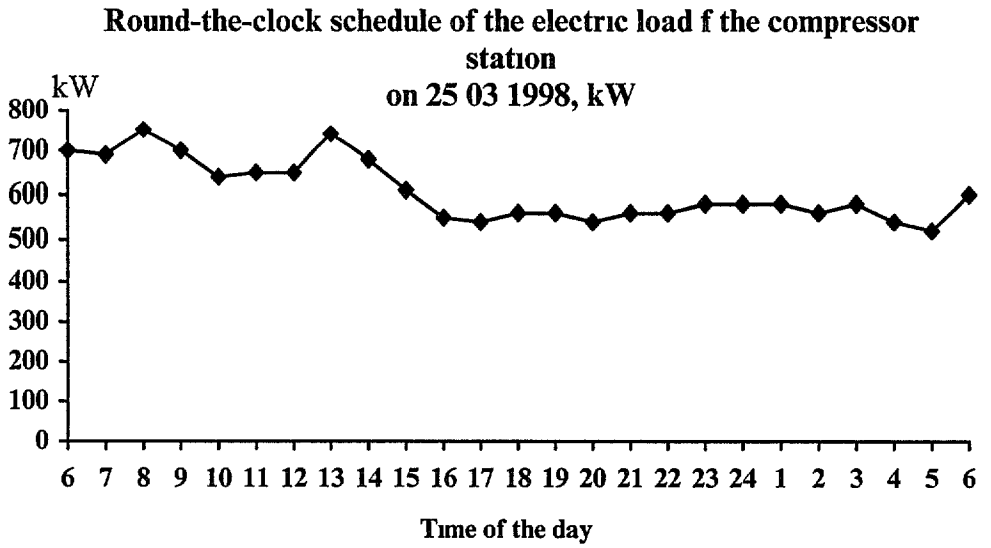

Fig 3 2

The pipeline supplying compressed air is put on a scaffold bridge (supports), it has no thermal insulation The main pipelines are circled within the workshops

Compressed air and its use by the main production shops and areas at the plant

Table 3 1

Consumers	%
Mechanic assembling workshop #4	30
Mechanic assembling workshop #3	24
Casting workshop	23
Mechanic assembling workshop #5	17
Pressing-and-thermal processing area	2
Other consumers	4

Distribution of the consumed air at the plant beween the basic plant users

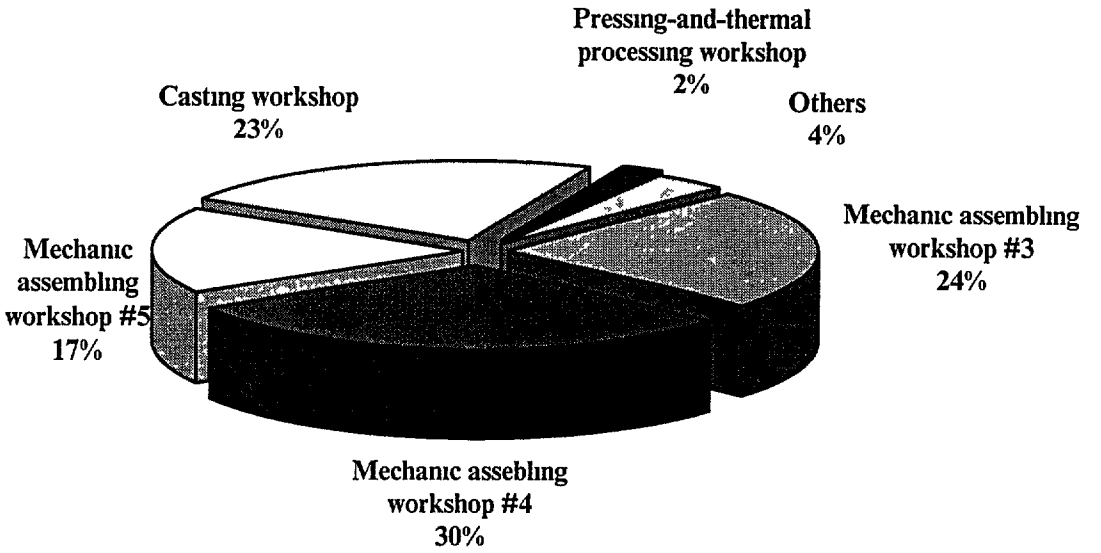

Fig 3 3

3 5 2 Thermal energy

The source of thermal energy (steam and hot water) at the plant is a boiler-house (for Production Ground #1) that is directly on the territory of the enterprise Saturated steam of the pressure of up to 3 barg is used for processing needs

Thermal energy consumption in 1997 was 47,690 Gcal
The basic energy using equipment is as follows

- electric plating tanks,
- washing machines in mechanic assembling workshops and on the pressing-and-thermal processing area,
- heaters in the hot water supply system,
- air screens and air-heating aggregates,
- other processing equipment

Hot water is used for processing needs, heating production areas and for hot water supply system

Distribution of thermal energy consumed by the basic units of the plant (Production Ground #1)in 1997 was as follows

Table 3 2

Consumers	Gcal	%
Heating	15,404	32
Hot water supply	1,243	3
Production needs	8,918	19
Everyday needs	2,746	5
Selling to off-plant users	19,379	41
Total	47,690	100

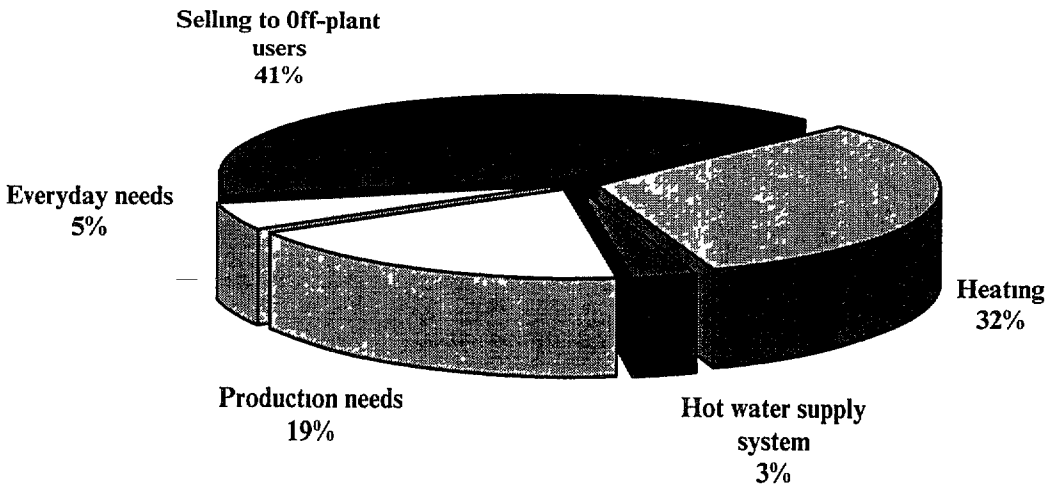

Fig 3 4

3 5 3 *Natural gas*

Natural gas is used at the enterprise for the boiler-house and for processing needs The basic gas consuming equipment is as follows

- the muffle-free aggregate, casting machines, painting-and-drying furnaces, pressing furnace and others

In 1997 gas consumption at production area #1 was 7,245,490,000 m^3 with a cost of US $579,639

The pressure of the used gas is up to 3 barg

Distribution of the gas consumption between the basic plant units (Production Ground #1) is as follows

Table 3 3

Consumers	m³ x 1,000	%
Boiler-house	6,369,261	88
Pressing-and-thermal processing workshop	772,500	10 5
Casting workshop	72,340	1
Others	31,389	0 5
TOTAL	7,245,49	100

Distribution of gas consumption between the basic plant units (Production Ground #1) in 1997

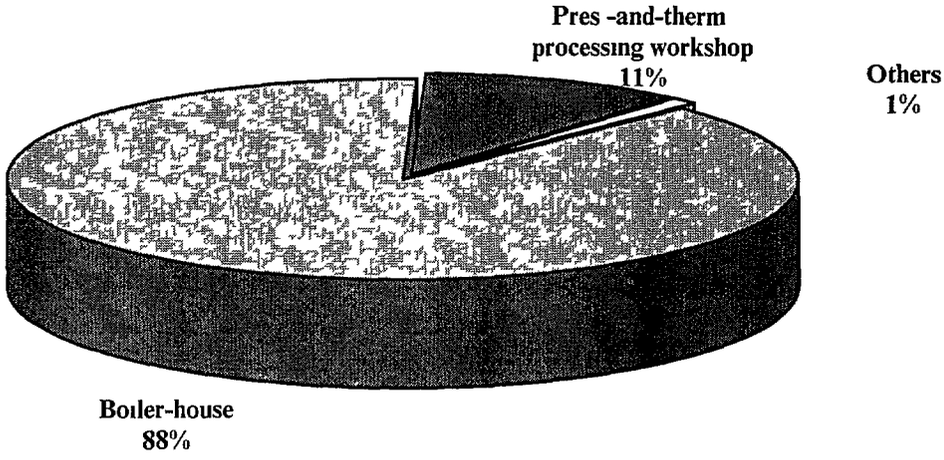

Fig 3 5

Use of natural gas is a prospective strategic trend from the point of view of energy saving at the plant as it is the cheapest energy source Up-to-date processing equipment allows to use effectively the heat obtained after burning gas in casting furnaces, infra-red heaters, air heat supply systems and in air screens

3 5 4 Electric power

Distribution in electric power consumption between the basic plant units (Production Area #1) is shown in Table 3 4

Table 3 4

Consumers	kW h x 1,000	%
Mechanic assembling workshops	1,747	12
Casting workshop	3,176	22
Pressing-and-thermal processing area	1,436	10
Compressor station	2,809	19
Boiler-house	1,918	13
Ancillary production	1,094	8
Utility sector	1,827	12
Others	572	4
Total	14,579	100

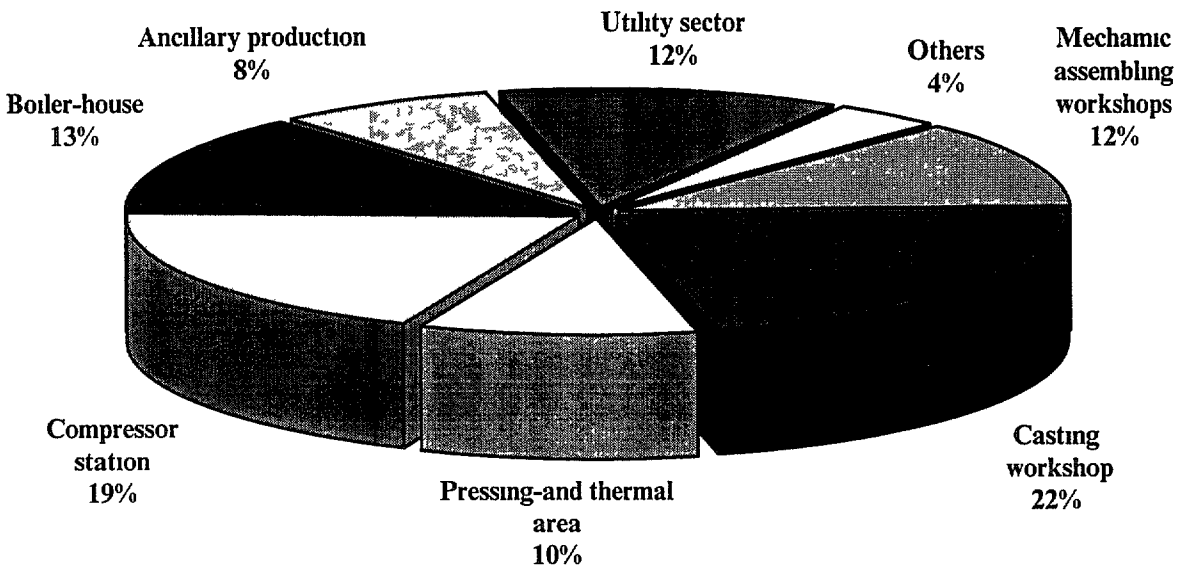

Fig 3 5

One of the basic users of electric power is electric drives for the processing, pump, compressor and ventilation equipment Significant use of electric power in the casting workshop is accounted for by the fact that the majority of the melting furnaces are electric Their main characteristics are as follows

Table 3 5

Furnace type	Power consumed, kW	Volume of the molten mass, kg	Time for melting from a cold state	Number of furnaces, unit
Induction-type *IAT-04*	150	400	7 hours	2
Induction-type *IAT-04*	350	1,000	8 hours	3
Resistive-type *NO-136*	41	180	10 hours	73

4 0 FINANCIAL STATUS OF PLANT

4 1 Currency vs Barter

Barter-based operations are 40 2% of the total sale (due to the data for 1997)

4 2 Viability of plant

Due to the economic situation in the country, production crisis, and in particular, in the machine-building industry, break of multiyear production co-operation with the enterprises that supplied spare parts on co-operative base, lack of money with the customers resulted in an incomplete use of the production facilities of the plant So, the capacity load of *"VZTA"* facilities was 31%

The profitability of the plant in 1997 was - 1 5% The debts concerning the payment for energy are canceled mainly on the mutual clearing basis The debt on March 1, 1998 (including the one for the previous year of 1997) was 866,109 hrn , it included 216,979 hrn for electric power, 3,534 hrn for thermal energy, and 645,596 hrn for fuel

The energy costs are 19 per cent of the value of the manufactured products

5 0 ANNUAL ENERGY CONSUMPTION AND COSTS

Energy consumption during the year is not stable, that is accounted for by the character of the production, which makes choosing the basic indicators for economic calculations and estimations of energy conservation opportunities still more difficult The peculiar scheme of arrangement of the basic production areas (existence of two Production Grounds #1 and #2 that are remote from each other and independent concerning energy consumption) adds in its turn to the energy balance of the plant

5 1 Annual consumption of natural gas and electric power in 1997

Production Ground #1 has an independent boiler-house that covers not only the processing needs of the plant, but it also provides thermal energy (steam and hot water) for some neighboring enterprises (the largest customer is the bakery) for the social sphere Production Ground #2 buys thermal energy from a closely located factory and, at the same time, it uses at its thermal station natural gas for hot water production

Table 5 1

Monthly distribution of thermal energy consumption for 1997

Month	Thermal energy, Gcal		
	Production Ground #1	Production Ground #2	Total for the plant
January	8,391	975	9,366
February	5,737	946	6,683
March	5,384	1,050	6,434
April	4,670	565	5,235
May	1,482	159	1,641
June	2,223	189	2,412
July	1,795	288	2,083
August	1,846	318	2,164
September	2,095	372	2,467
October	3,021	362	3,283
November	5,672	1,188	6,682
December	5,374	1,173	6,205
Total for the year	47,690	7,585	55,275

Annual consumption of thermal energy (Gcal)

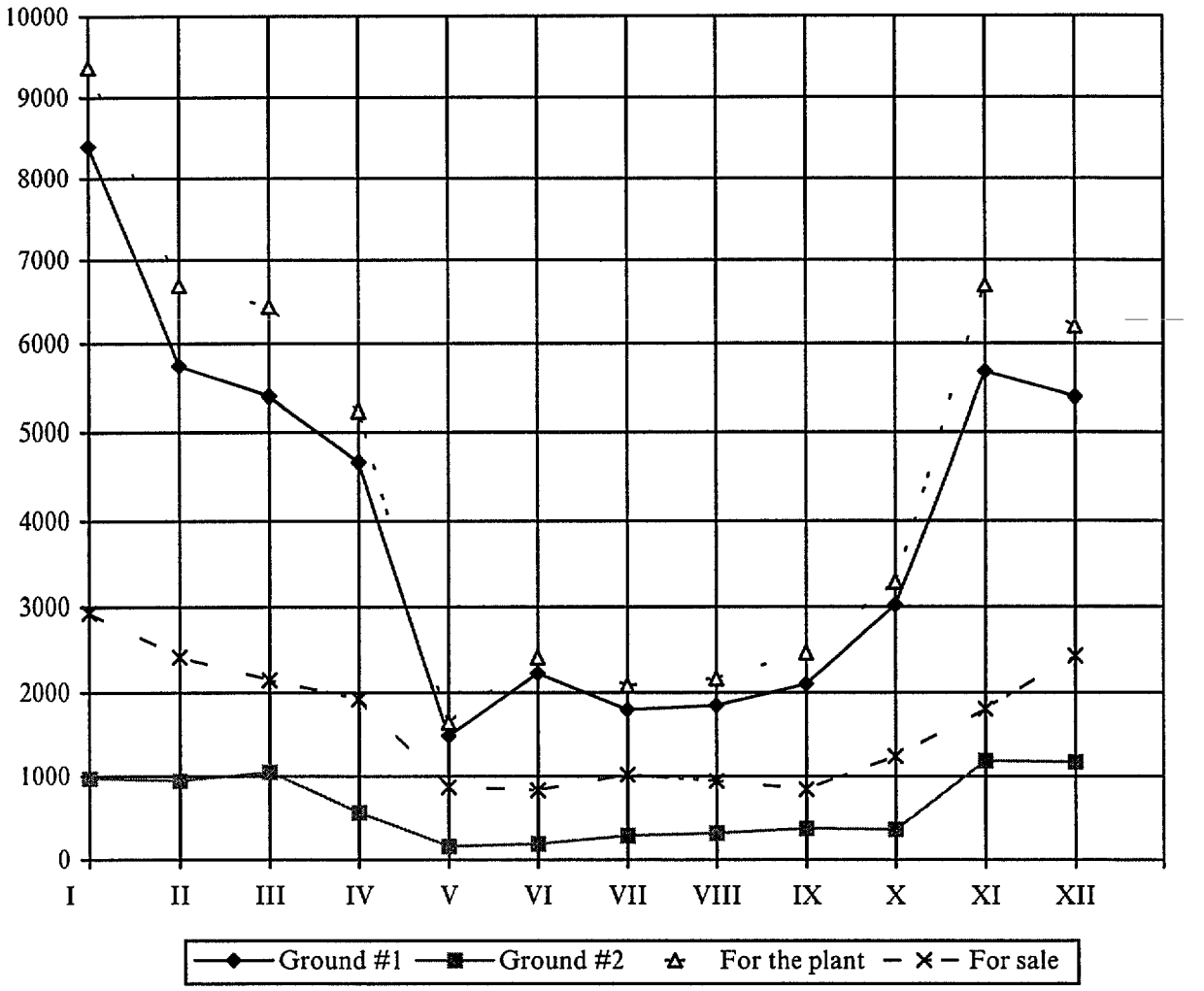

Fig 5 1

Consumption of thermal energy at the plant and selling it to the beyond-plant users is evidently of a seasonal character, which is accounted for by an uneven loading of the main production facilities (Production Ground #1) In the winter period the flow rate of thermal energy rises, as heating aggregates and systems are switched on

Balance of thernmal energy for the plant boiler-house in 1997

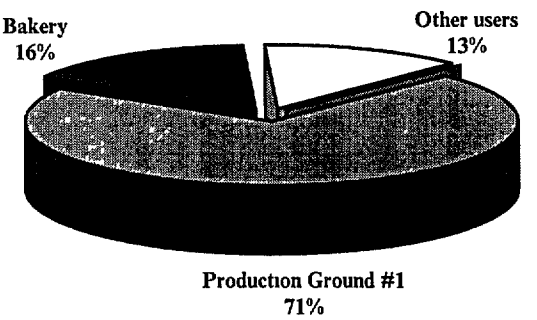

Fig 5 2

5 2 Annual consumption of natural gas in 1997

Natural gas is used at the enterprise both for the processing needs (thermal processing parts), and for the boiler-house (Production Ground #1) and the thermal station (Production Ground #2) for production of thermal energy

Table 5 2

Consumption of natural gas for 1997

Month	Natural gas, x 1,000 m³		
	Production Ground #1	Production Ground #2	Total for the plant
January	1,026	128	1,154
February	933	128	1,061
March	842	141	983
April	737	78	815
May	277	23	300
June	388	29	417
July	280	38	318
August	344	45	389
September	384	52	436
October	496	50	546
November	862	158	1,020
December	677	154	831
Total for the year	7,245	1,025	8,270
Costs, USD	579,600	82,000	661,600

* The tariff is US $80 per 1,000 m³ (including the transportation cost and the VAT)

The monthly consumption of natural gas is shown in Fig 5 4 Consumption of natural gas at Production Ground #2 is 14 per cent of the consumption level of that for Production Ground #1

Consumption of natural gas in 1997

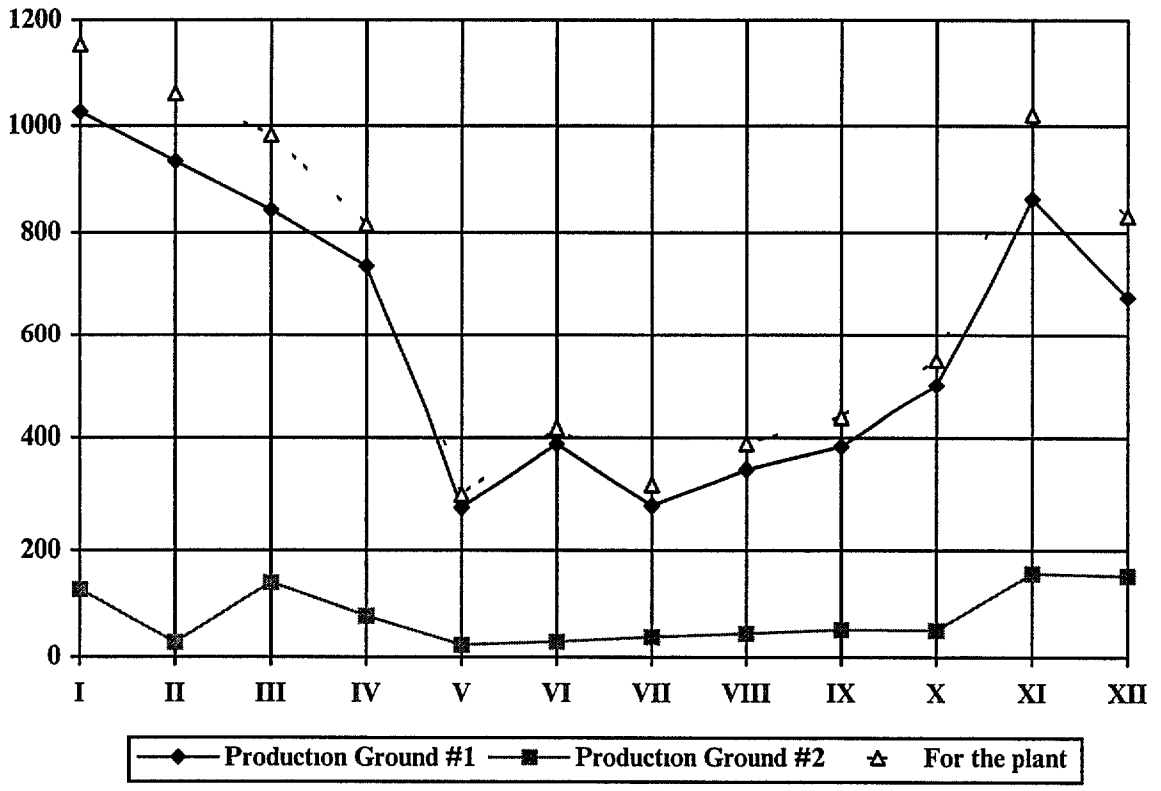

Fig 5 3

As it can be seen in the given figure that for almost 5 months in a year consumption of natural gas is below 30% of the maximum values for consumption, and it has an obvious seasonal character

5 3 Annual consumption of electric power in 1997

Table 5 3

Month	Electric power, x 1,000 kW h		
	Production Ground #1	Production Ground #2	Total for the year
January	866	716	1,582
February	1,601	640	2,241
March	1,493	723	2,216
April	1,521	596	2,117
May	1,159	332	1,491
June	1,317	367	1,684
July	305	146	451
August	1,427	352	1,779
September	1,683	494	2,177
October	1,266	466	1,732
November	1,458	519	1,977
December	483	460	943
Total for the year	14,579	5811	20,390
Costs, USD	524,844	208,196	734,040

Consumption of electric power is shown in Fig 5 4

Consumption of electric power

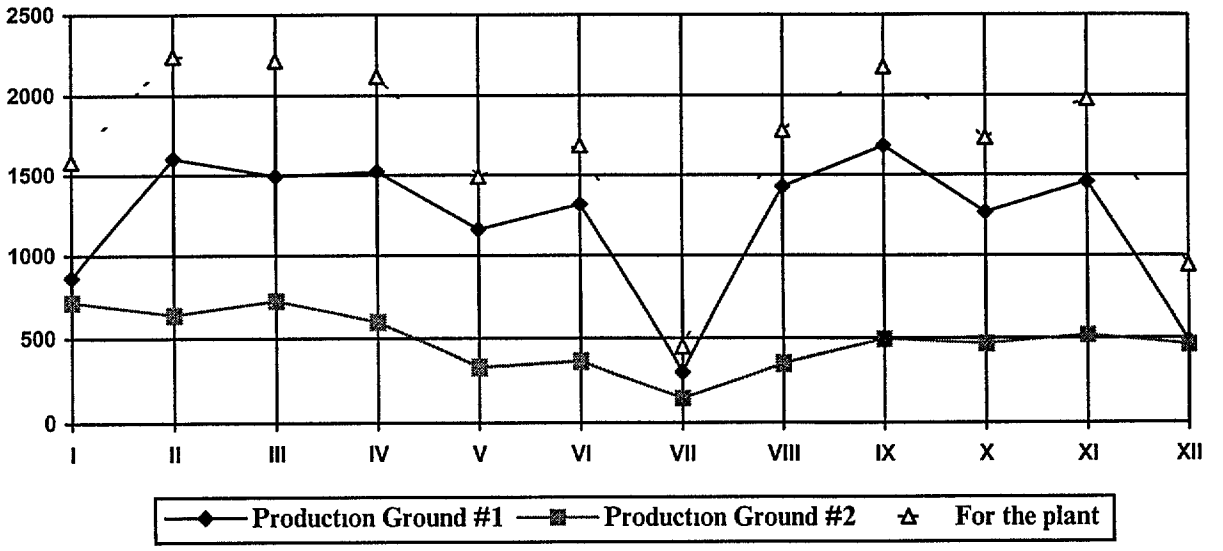

Fig 5 4 Consumption of electric power

The schedule of the yearly consumption of electric power shows loading the production facilities during a year A decrease in electric power consumption in January, July and December 1997 is accounted for by shutting down of the basic production facilities, the following gradual rising in the electric power consumption is accounted for by loading of the production facilities In winter period the flow rate of electric power increases as the heating-and-ventilation systems are put into operation

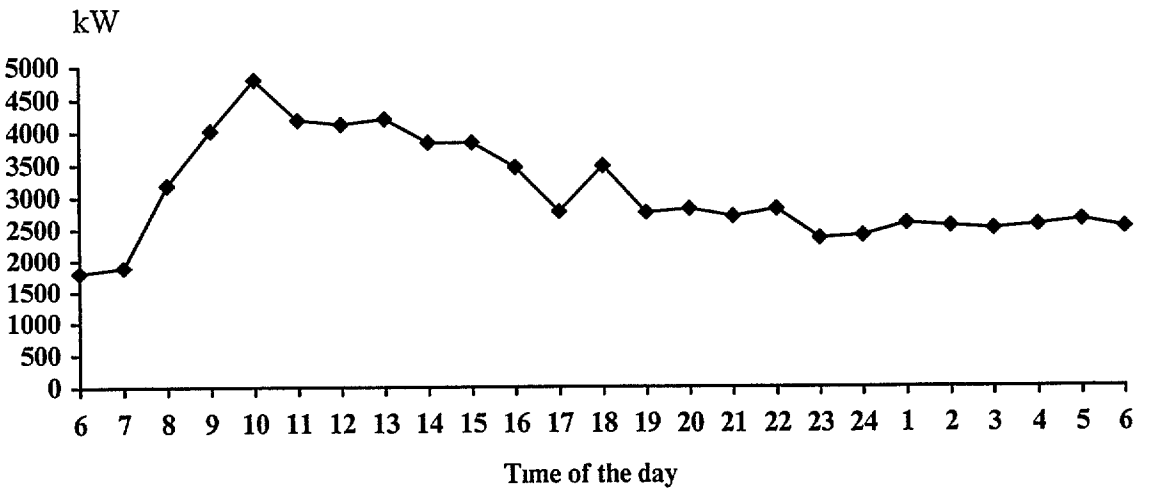

Fig 5 5 Daily schedule
of electric power consumption by Production Ground 1 on March 25, 1998, kW

The majority of the production workshops and areas at the enterprise work on a one-shift basis, the working day starts at 7 to 8 A M and finishes at 3 30 to 4 30 P M Only the compressor station, Casting Workshop #4 and the muffle-free aggregate operate 24 hours round However, as it is seen in Fig 5 5, the night load is about 50 per cent of the maximum one

5 4 <u>Current tariffs on electric power and fuel in 1997</u>

- 1 Gcal of thermal energy (that is bought) - 56 78 hrn (US $28 36)
- 1 kW h costs - US $0 04

- 1,000 m^3 of natural gas cost - US $80

5 5 Structure of the total electric power consumption and its cost in 1997

The structure of electric power consumption and its cost is shown in Table 5 4

Table 5 4
Electric power consumption and its costs

Energy	Consumption	Cost, US $	%	Gcal*	%	USD/Gcal
Electric power	20,390,000 kW h	734,040	53	17,535	21	42
Natural gas	8,270,000 m^3	661,600	47	66,904	79	10
Total	—	1,395,640	100	84,439	100	

* 1,000 m^3 = 8 09 Gcal, 1,000 kW h = 0 86 Gcal

Analysis of the consumption of electric power suggests that a prospective direction from the point of energy saving is the use of natural gas

5 6 Metering consumption of energy sources

Thermal energy

Measuring assemblies and units for metering the parameters of the heat-transfer agent and the condensate at the plant are not available Commercial metering of the consumption of heat and the heat-and-transfer agent parameters is done at the bakery daily The information is entered into the register in the Chief Energy Engineering Department In the end of a month bills for payment are claimed from the side of *VZTA* The energy consumption used for hot water supply and heating needs is calculated

Electric power

The electric power supply system at the OJSC *"VZTA"* includes currently a distributing substation *RP-13* (10 kV) that is powered from the substation *"Vostochnaya"* (110/10 kV), three distributing devices *RU-1, RU-2, RU-3* (10 kV) Besides, there is an input through *RU-5* The circuit is sectioned, of the radial type

In the high-voltage circuit each of the four inputs includes an installed commercial meter of the active and reactive power (8 units) Additionally there is metering of the consumption for the utility sphere (2 meters)

Technical metering is provided for all *RU*s (the total number is 30, for the active and reactive power) Readings of the meters from the input feeders of the meters are registered every day in a special register book The data concerning the daily consumption of the electric power by the plant is regularly transferred from the beginning of a month to the energy supplying company During heavy loads the readings of the meters are registered every other half an hour, and the value of the electric power totally consumed by the plant is calculated There is no continuous control of electric power consumption, as there is no any metering system meeting the requirements The registration system *TsT 5000* installed at the plant currently does not work

consumption, as there is no any metering system meeting the requirements The registration system *TsT 5000* installed at the plant currently does not work

Natural gas

Commercial metering of consumption of natural gas is accomplished by means of *DSS-711* measuring instrument whose speed operation is as follows

- Gas Distribution Station #1 Q_{max} = 1,600 m³/h, Q_{min} = 480 m³/h (30%),
- Gas Distribution Station #2 Q_{max} = 2,000 m³/h, Q_{min} = 600 m³/h (30%)

These meters are only capable of reading minimum value at thirty per cent of full scale

There is no computer-based metering of the gas consumption with the precision of ±1 per cent The balance in regard of the gas consumption by the basic plant structural units is made on the basis of the readings from *RG*-type sensors and approximate calculations

Taking into account that the majority of the plant operates one-shift and the existence of gas-consuming processing lines that are operating around the clock, it is easy to see that the time when consumption of gas is less than 30 per cent of the maximum flow-rate of the meter is as much as 20 - 30 per cent of the total time (that is the plant pays for more than it has used in fact)

6 0 PREVIOUS ENERGY CONSUMPTION COST

6 1 The plant has no program of energy management, though some of the corresponding tasks are in charge of the Chief Energy Engineer

Projects aimed at improvement of the plant energy facilities were begun in the 80's, when the plant was under reconstruction All changes were caused by the changes in the production level

6 2 At the plant there is a plan of measures aimed at saving fuel and energy resources in 1998

The basic measures are.—

Electric power

- Changing the processing of making castings, covers, bushings and compensators
  Saving — 23,000 kW h
- Changing the design of covers and bodies
  Saving — 5,200 kW h
- Introduction of mobile compressors
  Saving — 230,000 kW h
- Installation of two devices for temperature control in the *NO-136*-type melting furnace
  Saving — 52,000 kW h

Thermal energy

- Changing the composition of the fuel for the boiler-house by emulsification mazut
  Saving — 137 Gcal
- Transfer of the heating system in Machine-Assembling Workshop #4 on overheated water
  Saving — 82 Gcal
- Introduction of gas water heaters with low gas consumption
  Saving — 168 Gcal

The planned measures are associated with the available reserves in energy saving Some measures require feasibility studies and calculations of the cost on their implementation with the aim of estimating their payback periods and making a decision whether they should be included into the financial plan of the plant

7 0 ENERGY AUDIT

7 1 Specific energy consumption in 1997

At the enterprise there are developed standard rates of energy consumption by certain types of plants and for certain processes per product unit However, because there is no sub-metering of energy resources consumed in each basic production areas and process, the consumption rates are theoretical, and they cannot be used to assess the implemented energy saving measures

7 2 Energy conservation measures

Implementation of energy management program (ECO - 1)

It is typical for industrial plant management to mainly think in terms of production, and to want to increase its output Therefore it is sometimes difficult to think of the importance of energy and energy costs on the operation of the plant

At the OJSC *"VZTA"*, as with most industries in Ukraine, in the past the energy costs were significantly subsidized and plentiful, and the energy saving was not a major consideration in the plant operations

With the rising energy costs during the past few years, the energy costs have become very influential part of expenses

Currently at the OJSC *"VZTA"*, like at other Ukrainian enterprises, though the problems in relation of the energy resources and energy costs are now well understood by the staff, there is a tendency to think of implementing large projects with the intent of saving large amounts of energy by saving energy sources And at the same time at the facilities a large number of small energy saving projects exist that have short payback periods

Most industries in Ukraine have a person or persons who are referred to as energy engineers These people are typically responsible for ensuring that there is an adequate supply of energy to the plant, not to improve the energy efficiency of the plant, But with the rise in energy prices and the uncertainty of availability of all fuels, an energy manager becomes important Each plant should seriously consider establishing an energy manager position as a minimum, and for large industries, possibly even an energy management section

These people should be regularly monitoring all operations, and especially reviewing monthly energy consumption This monthly data should be graphed and compared to previous months and years to determine any variations in consumption Where variations do occur, they should then determine the cause of the variation and if remedial action is required For instance, if monthly consumption increases, the reasons why should be determined and if appropriate, steps taken to correct any problem

In addition, the energy management staff should also review each process, and look for energy saving opportunities They should see that all cost effective energy improvements are implemented, beginning with the items identified in this energy audit

It is proposed to provide for the enterprise required measuring instruments in order to identify and assess quantitatively energy conservation opportunities (ECOs), independently determine the priority

of costs for energy saving purposes, to decrease energy consumption and to control energy consumption

The expected saving
- of electric power - 1,019 5 kW h that cost USD 40,780,
- of natural gas - 414,000 m^3 that costs USD 33,120,

Projects costs - USD 62,950,
Payback period - 0 8 year

Automatic systems for metering energy consumption (ECO -2)

The currently existing system for metering the total consumption and distribution of electric power, thermal energy, hot and cold water does not enable analysis of the energy efficiency at the plant

The system for metering the energy consumption at the plant based on calculated rates is insensitive to the energy saving measures Estimation of the expected energy saving seems to be problematic, the same is valid for the costs of the energy conservation measures

It is proposed to up-grade the available system for metering energy consumption *ITEK* and *SuperFlows* equipment that have measuring characteristics designed for continuous or regular (express-analysis) checking/recording of physical values

Expected saving is USD 90,640, in that

- electric power — 612,000 kW h that cost USD 24,480,
- natural gas — 827,000 m^3 that cost USD 66,160,

Project cost - USD 93,000
Payback period - 1 0 year

Optimization of burning gas in the steam boilers (ECO - 3)

Highly efficient burning of gas in the steam boilers requires supporting an optimal gas-to-air ratio, its regular control and adjustment

In the boiler-house the combustion mode is identified visually, without making analysis to determine the contents of such gases as O_2 and CO that determine the fuel combustion efficiency

It is proposed to introduce into practice at the plant a portable combustion analyzer, to train a specialist operating it to perform a regular control and adjustment of the combustion mode, which will provide rising of the boiler efficiency and saving natural gas

Expected saving
- natural gas — 95,600 m^2 that cost USD 7,648

The project cost — USD 7,000
Payback period— 0 9 year

Repair of compressed air leaks (ECO - 4)

The plant has a very branched system of compressed air supply While walking on the territory of the plant, leaks of compressed air were seen on the equipment that was not being operated Leaks were seen on disassembled connections of pipe lines The shut off valves were not activated when non-operated production areas were disconnected In addition, the compressed air system is not controlled

In 1997 consumption of compressed air amounted to 35,280,000 m^3, its production required use of 2,809,000 kW h that cost USD 101,124

It is proposed to use at the plant a portable detector of gas and air mixture leaks which will allow to check regularly threaded and flanged connections, fixture and equipment sealing and repair leaks in due time The experts suppose that this measure will allow to save at the plant not less than 2 per cent of the compressed air losses

Expected yearly saving of compressed air - 705,600,000 m^3 or 56,200,000 kW h that costs USD 2,247

Project cost	- US $2,000
Payback period	- 0 89 year

Replacement of lighting lamps in Mechanical and Assembling #5 (ECO - 5)

In production rooms in Mechanic and Assembling Workshop #5 for its lighting there are used 90 mercury high-pressure *DRL-700* with the corresponding starting-up device

It is proposed for consideration a project of replacement the high-pressure mercury lamps of *DRL*-type used for lighting in Mechanical and Assembling Workshop #4 with *DNaT-400*-type high-pressure potassium lamps at the same time retaining the same lighting fixture and replacing the starting devices of the corresponding capacity The illumination flux for *DRL-700* lamp is 47,000 Lm, while its nominal life time is 6,000 hours *DNaT-400* high-pressure lamps of Ukrainian production (Poltava City) have a longer life time - 12,000 hours - at the illumination flux of 47,500 Lm

Expected yearly saving of electric power	- 99,000 kW h or USD $3,962
Project cost	- USD 3,960
Payback period	- 1 0 year

Gas-fired infra-red heating systems (ECO - 6)

The production rooms at the plant are heated by means of air heating systems The basic type of heat-using equipment are calorifers that operate on hot water or steam As it is known from practice and from the world practice, the existing heating systems are not efficient, especially under condition of a lot of spare areas available and working only in one shift There is no at the plant system for automatic supporting the temperature in the rooms during the working hours

Taking into account availability at the plant of natural gas, there is proposed to install at Production Ground #2 in some workshops or production areas infra-red gas-fired heating systems

Expected yearly savings	
of natural gas	- 8 ,010 m^3 USD 640
of thermal energy	- 720 Gcal or USD 10,800 (in total USD 11,440)
Project cost	- USD 19,030
Payback period	- 1 7 years

Steam electric power generating plant (ECO - 7)

The steam boilers in the boiler-house that generate thermal energy in form of 11 to 12-barg saturated steam The stream using equipment at the plant operates on saturated steam with the pressure of up to 3 5 barg In the boiler-house the pressure is decreased from 12 to 4 barg by means of a reduction plant Decreasing the steam pressure in the reduction plant is a non-recovered energy loss

It is proposed to use the energy of the steam pressure reduction in the boiler-house for independent generation of electric power For that there is proposed, in parallel with the reducing plant, to use a steam electric power generating plant of *PVM-250-EG*

The proposed measure will allow the enterprise to generate in the boiler-house electric power with the capacity of 175 kW per hour and approximately decrease the electric power costs by 6 per cent

Expected annual saving of electric power consumption	- 875,000 kW h or USD 35,000
Project cost	- USD 68,500
Payback period	- 1 96 years

Transfer of *NO-136* melting furnaces on natural gas (ECO - 8)

At the plant for melting the secondary aluminum they use electric melting furnaces of *NO-136*-type that were designed at the plant for melting of 180 kg of aluminum

Melting of metal by converting electric energy into thermal requires substantial financial costs, as 1 Gcal of heat received from electric energy costs USD 42, while burning natural gas costs USD 10

It is proposed to perform modernization of the melting furnaces of *NO-136*-type to use natural gas

Expected annual saving	- USD 117,400
Project cost	- USD 140,250
Payback period	- 1 4 years

8 0 EFFECT OF IMPLEMENTING THE RECOMMENDATIONS ON ENVIRONMENT

Saving energy resources is directly connected with decreasing the harmful emissions into the environment

Initial data for calculations

The average amount of harmful emissions per 1,000 kW h of the electric power produced in 1996 according to the data from the Ministry of Energy of Ukraine was as follows

CO (carbon monoxide) - 0 51 kg
No_x (oxides of nitrogen) - 2 177 kg
SO_2 (sulfur dioxide) - 9 89 kg
Particulate - 4 365 kg

To estimate the reduction of harmful emissions into the atmosphere from energy conservation improvements, average values of specific emissions per 1,000 m^3 of natural gas used when burning natural gas in the steam boilers (*DKVR*-type operated at the plant)

CO - 0 03 to 0 04 kg/Gcal (the average value is 0 035 kg/Gcal or 0 28 kg per 1,000 m^3 of burned natural gas)
NO_x - 0 14 to 0 16 kg/Gcal (the average value is 0 15 kg/Gcal or 1 215 kg per 1,000 m^3 of burned natural gas)

Calculation of the decrease of harmful emissions into the atmosphere

- Expected yearly saving providing implementation of the ECO
  - natural gas - 1,433,000 m^3
  - electric power - 2,661,700 kW h
  - thermal energy - 720 Gcal,
- Decrease of harmful emissions into the atmosphere

CO - 1,344,600 m^3 0 28 kg/10^3 m^3 + 720 Gcal 0 035 kg/Gcal + 2,661,700 kW h 0 5 kg/10^3 kW h = 482 kg + 25 kg + 1,331 kg = 1,838 kg
NO_x - 1,344,600 m^3 1,215 kg/10^3 m^3 + 720 Gcal 0 15 kg/Gcal + 2,661,700 kW h 2 2 kg/10^3 kW h = 1,634 kg + 108 kg + 5,856 kg = 7,598 kg
SO_2 - 2,661,700 kW h 9 9 kg/ 10^3 kW h = 26,351kg
Ash - 2,661,700 kW h 4 4 kg/10^3 kW h = 11,711kg

The total decreasing of the harmful emissions - 47 498 tonnes per year

APPENDIX A ENERGY CONSERVATION OPPORTUNITIES (ECOs)

Energy Conservation Opportunities

ECO - 1	**Implementation of energy management program**
ECO - 2	**Automatic systems for metering consumption of energy resources**
ECO - 3	**Optimization of gas combustion in the stream boilers**
ECO - 4	**Repair compressed air leaks**
ECO - 5	**Replacement of lighting lamps in production rooms in Workshop #5**
ECO - 6	**Steam electric power generating plant**
ECO - 7	**Infra-red gas-fire heating systems**
ECO - 8	**Transfer of *NO-136* melting furnaces of burning natural gas**

Energy Conservation Opportunities

ECO - 1 Implementation of energy management system

Description of the opportunity

The basic instrument in decreasing energy consumption by using it more effectively is energy management Energy management is a management system based on fulfilling typical measurements and checks providing such an operation of the plant when there is consumed only the amount of energy required for the processing needs The plant management is aware of the benefits of energy efficiency, but there are no technical facilities for quantitative assessment of the financial advantages of the energy saving measures

While performing the audit there were found a lot of low-cost and no-cost energy saving opportunities that can become of a significant benefit

For example, estimation of the efficiency of operating melting furnaces, fans and other similar equipment will allow the operation of the most efficient equipment and to discontinue use of the inefficient equipment

Introduction of an energy management system at the enterprise will provide a quantitative and qualitative assessment of energy saving opportunities

It is proposed to provide for the enterprise the required measuring instrumentation to identify and quantitatively assess the energy saving opportunities, as well as independently determine the priority of the costs on energy saving and to decrease energy consumption and monitor energy saving

The set of the equipment that would be useful for the plant should include the following

- a non-contact thermometer
- a wire thermo-anemometer
- a three-phase energy analyzer
- a tachometer
- a digital contact thermometer
- an illumination meter
- an ultrasonic flow meter
- a power meter
- a power factor meter
- a portable temperature/humidity/'dew point" recorder
- a computer with a printer

If a set of portable devices is available, there is proposed to introduce at the plant a position of the energy manager It is reasonable for the energy manager to undergo a special training course in the Energy Managers Training Center (Kyiv City, National Technical University of Ukraine "Kyiv Politechnical Institute") The basic task of the energy manger is monitoring of energy using systems, development of real rates with the aim of continuous monitoring for their observation by the energy users and decreasing the total energy consumption at the plant

The issues of the energy manager should include the following aspects

- training the plant personnel on energy management practice,

- encouraging plant personnel in finding energy conservation opportunities at their production areas and in their workshops,
- awarding the plant personnel for finding potential energy conservation opportunities,
- quantitative estimation of the economic effect for each of the energy conservation opportunities and of the payback period for the corresponding investments,
- planning and correction of a 5-year strategy plan of the energy management development aimed at implementation of energy conservation opportunities,
- applying for allocation of funds for on energy saving projects,
- implementation of energy conservation opportunities if they are financed or no-cost,
- following-up of the energy conservation opportunities after their implementation and a quantitative assessment of the actual saving of the costs,
- dissemination of the successful experience of implemented energy conservation projects as well as their lessons,
- repetition of successful energy conservation projects at all production areas and in all workshops at the given plant

Calculation of yearly savings of costs

The world experience and practice prove that implementation of an energy management system by using the above equipment can give a yearly energy saving of no less than 5 per cent

The energy saving will be as follows

1 Electric power 20,390,000 kW h • 0 05 = 1,019,500 kW h
2 Natural gas 8,270,000 m^3 • 0 05 = 414,000 m^3

Calculation of yearly savings of costs

1 If 1,000 kW h cos USD 40, the saving of the electric power cost will be
1,019,500 kW h • USD 40 = USD 40,780
2 If 1,000 m^3 cost USD 80, the saving of gas costs will be
414,000 m^3 • USD 80 = USD 33,120

The total saving of the energy costs will be
USD 40,780 + USD 33,120 = USD 77,900

Commissioning costs

Approximate cost of a set of the measuring instruments is USD 24,000
The costs of implementation of an energy management system, as it is shown by practice, are about 50 per cent of the expected saving, or USD 77,900 • 0,5 = USD 38,950

The total costs are USD 24 000 + USD 38,950 = USD 62,950
The simple payback period is USD 62,950 USD 77,900 = 0 8 year ≈ 10 months

ECO - 02 **Automatic systems for metering consumption of energy resources**

Description of the opportunity

The currently existing scheme for metering of the total consumption of thermal and electric power and their distribution as well as that for the hot and cold water does not allow operational analysis the efficiency of the energy consumption at the plant

The system for metering the consumption of the energy resources at the plant based on the theoretical standardized rates is insensitive to the energy saving measures It seems quite difficult to objectively estimate the expected saving of the energy resources and to have a guarantee for the used resources to be paid back after implementation of the energy saving measures

It is proposed to perform upgrading of the current energy consumption metering system As a variant, for the upgrading a set of technical instruments is proposed to be used (*ITEK*) that has metrological characteristics and is designed for continuous or regular (express-analysis) measurements/recording of physical parameters

Introduction into practice of *ITEK* allows its users to pay for electric power according to a one-rate tariff that is different due to the day time zone, which together with the measures aimed at decreasing the energy consumption in the peak hours gives a significant economic effect, the latter has been proved repeatedly by a yearly operation of a lot of Ukrainian objects

ITEK-210 and *ITEK-310* are designed for commercial and technical metering of the electric power consumption (that is different in time) and for making automatic metering systems for metering and monitoring electric power consumption together with electric power consumption meters - those three-phase induction ones that are provided with pulse formation devices (such as *E*440, *E*870, *UP*-1, *UP*-2, *UP*-3, *SU*-500), or electronic ones (produced by *Siemens*, *Landis&Gyr*, *Alpha-ABB*, etc) that have a pulse output They support 64 (for *ITEK-210*) or 12 (for *ITEK-310*) metering channels, 4 tariff zones, a round-the-clock schedule for all the metering channels - minimum 5 days, 2 independent information interface

ITEK-210 can be used together or instead of the installed *TsT5000* systems by connecting to the existing matrix of the primary transducers *ITEK-210* is included into the State Measuring Instruments Register of Ukraine

ITEK-410 is a device of 4 metering channels that is similar to the above ones It supports in addition the tariffs that are differentiated due to energy and power, as well as traces the consumption process and controls it (if this mode is activated) The daily schedules in relation to 4 channels are saved for no less than 1 month

Introduction into practice of *ITEK-X2X* allows the users to perform metering the consumption of energy resources with a high precision and pay for the used recourses not according to the fact but in proportion to the used area

ITEK-220, *ITEK-320* are designed to be used in automatic systems for commercial and telemetric monitoring of the provided and consumed liquids, steam and thermal energy together with any standard primary transducers for measurements of flow rate, temperature and pressure differences that have rated output parameters, at the suppliers' (Heat Power Plants, heat and power supply lines, boiler-houses) and at the consumers' (industrial plants, utility objects) The design of *ITEK-X20* meets the requirements of *RD-50-213-80, PR34-70-010-85, GOST 6651-84* and *R75 MOZM ITEK-220*, *ITEK-320* are designed to be used a the objects belonging to Metering Group 1 (up to 4 objects) of a

complicated network of the inlet and outlet pie lines (*ITEK-220*) and to Metering Group 1 and 2 (1 objects) (*ITEK-320*)

For implementation of the measure it is reasonable to provide the following

- commercial control of the electric power consumption in the current 5 check-points,
- technical metering of the electric power consumption on the territory of the plant in 7 check-points,
- technical metering of the steam consumption in 6 checking-points,
- technical metering of the hot water consumption in 3 check-points,

Taking into account the need to install meters of natural gas of the precision class not lower than 1 in two commercial inlet check-points, there is expedient installation of "*SuperFlow*" metering system

Calculation of a yearly energy saving

Electric power consumption for 1997 was about 20,390,000 kW h, that of natural gas was 8,270,000 m^3

The practice shows that implementation for the plant of an independent automatic system for metering, planning and monitoring consumption of energy resources will decrease the consumption of energy resources not less than by 3 per cent, and the consumption of natural gas - not less than by 7 to 10 per cent, which in total will be as follows

1) electric power saving 20,390,000 kW h • 0 03 = 612,000 kW h,
2) natural gas saving (827,000 m^3)
   by using thermal energy 8,270,000 m^3 • 0 03 = 248,000 m^3,
   resulting from implementation of metering gas consumption 8,270,000 m^3• 0 07=579,000 m^3

Calculation of yearly costs

1 If 1,000 kW h cost USD 40, the saving of electric power costs will be
   612,000 kW h • USD 40 = USD 24,480
2 If 1,000 m^3 cost USD 80, the saving on gas costs will be
   827,000 m^3 • USD 80 = USD 66,160

The total energy saving will be
   USD 24,440 + USD 66,160 = USD 90,640

Commissioning costs

The approximate cost of an automatic metering system will be USD 93,000

The simple payback period is USD 93,000 USD 90,640 ≈ 1 0 year

ECO - 3 Optimization of burning gas in the steam boilers

Description of the opportunity

Highly efficient burning of gas in the steam boilers requires supporting an optimal gas-to-air ratio, its regular control and adjustment

In the boiler-house the combustion mode is identified visually, without making analysis to determine the content of such gases as O_2 and CO that determine the fuel combustion efficiency

"Scheduling" the operation modes for the steam boilers DKVR-20/13 #3 by means of a portable combustion analyzer "BACHARACH" showed a real opportunity to save gas by 1 5 to 2 0 per cent

It is proposed to introduce into practice at the plant a portable combustion analyzer, to train a specialist operating it to perform a regular control and adjustment of the combustion mode, which will provide increasing the boiler efficiency and savings of natural gas

Calculation of yearly saving of natural gas consumption

1 Improvement of the efficiency of the equipment (set) — 1 5%
2 Yearly gas consumption at the boiler-plant (in 1997) — 6,370,000 m^3
3 Expected yearly gas saving
   6,370,000 m^3 • 0 015 = 95,600 m^3

Calculation of a yearly saving of costs

1 1,000 m^3 of gas cost USD 80
2 Yearly saving
   95,600 m^3 • USD 80 = USD 7,648

Commissioning costs

The portable gas analyzer *"ENERAC 2000"* with sensors of O_2, CO, NO_x, SO_2 and with probes of 12 and 48 inches (taking into account the transportation and other costs) costs about
USD 7,000

The simple payback period is USD 7,000 USD 7,648 = 0 9 year ≅ 11 months

ECO - 04 Repairing compressed air leaks

Description of the opportunity

The enterprise has a branched network of compressed air ducts While walking around the workshops compressed air leaks were found at the non-operated equipment The leaks were observed at the detachable joints of the pipe lines of the stamping and pressing equipment The stop valves for disconnecting the non-operated areas and workshops were disabled

There was no control of the compressed air supply In 1997 the total production of the compressed air was 35,280,000 m^3 that required consumption of 2,809,000 kW h of electric power at a cost of USD 101,124

It is proposed to use at the enterprise a portable detector of gas and air mixture leaks, which will enable regular checking of the threaded and flanged joints, fixture and equipment seals as well as to eliminate the leaks This will permit, in the opinion of the experts, to decrease the compressed air losses at the enterprise not less than by 5 per cent

The practice of operating equipment consuming the compressed air shows that, at the pressure of 5 kg/cm^2, a hole with the diameter of 1 mm leads to a loss of 3 5 m^3/h, which corresponds to losing annually 18,600 m^3 or US $141 (supposing a 5-day working week and disconnection of the compressors for the weekends)

Calculation of the expected saving

1	Average annual compressed air consumption expected in 1997	-	35,280,000 m^3
2	The amount of electric power used to generate the said amount of compressed air (according to the data given at the plant)	-	2,809,000 kW h
3	The expected decrease in consumption of compressed air (and that in electric power for its production)	-	5 %

4 The expected saving

2,809,000 kW h 0 05 = 140,500 kW h

5 Cost saving

140,500 kW h USD 0 04 = USD 5,618

Suggested equipment and its cost

The cost of a portable gas and air mixtures detector with taking into account the transportation and other expenses US $2,000
The plant needs 1 portable detectors
The total cost USD 2,000

The simple payback USD 2,000 USD 5,618 = 0 36 year ≅ 4 months

ECO - 05 Replacement of the lighting lamps in the production rooms in Workshop #5

Description of the opportunity

The lighting system in the production rooms in Mechanical and Assembling Workshop #5 includes the following lighting equipment

- *DRL-700* - 90 units (the total capacity is 63 kW),
- *LD-2x80* - 8 units

It is proposed to consider a project of replacing the *DRL-700* lamps used for lighting of the production rooms in Mechanical and Assembling Workshop #5 with high-pressure sodium lamps of *DNaT-400*-type while using the currently existing fixture and replacing the existing starting devices of the corresponding capacity The light flux of a *DRL-700* lamp is 47,000 Lm, and its nominal operation time is 6,000 hours A *DNaT-400* sodium high-pressure lamp of the Ukrainian production (Poltava City) has a long life time - it is 12,000 hours with the light flux of 47,500 Lm

Calculation of the annual energy saving

Electric power consumption by an illuminant equipped with a *DRL-700* mercury lamp

$P_{il1} = (P_{l1} + P_{S1})$ cosφ,

where

P_{l1} = 700 W is the power capacity of a *DRL-700* lamp,

P_{S1} = 190 W is the power capacity of the starting device,

cosφ = 0 98

P_{il1} = (700 + 190) 0 98 = 891 W or 0 891kW

The annual electric energy consumption by 90 fixtures averaging 8 hours per day is

$P_1 = P_{il1}$ n F,

where

n=90 is the number of the illuminants,

F=8 305 = 2 440 hours - the annual stock of the illuminant operation time,

P_1 = 0 891 90 2,440 = 195,664 kW h

The electric power consumption by an illuminant equipped with a *DNaT-400* sodium lamp

$P_{il2} = (P_{l2} + P_{S2})$ cosφ,

where

P_{l2} = 400 W is the power capacity of a *DNaT-400* lamp,

P_{S2} = 40 W is the power capacity of the starting device,

P_{il2} = (400 + 40) = 440 W or 0 44 kW

The annual electric energy consumption by 90 fixtures averaging 8 hours per day is

$P_2 = P_{il2}$ n F = 0 44 90 2,440 = 96,624 kW h

The annual electric power saving in the physical terms if operating *DNaT-400* lamps

$P_1 - P_2$ = 195,664 kW h - 96,624 kW h = 99,040 kW h

Calculation of the annual cost saving

The annual cost saving at US $0 04/kW h

99,040 0 04 = USD 3,962

The cost of commissioning

The cost of *DNaT-400* lamps with a new electronic starting device - 90 units at USD 44 per unit
the total cost USD 44 90 units = USD 3,960

Installation costs are not taken into consideration as the work is to be performed by the plant itself

The simple payback period USD 3,960 USD 3,962 ≅ 1 0 year

ECO - 06 Infra-red gas-fired heating systems

Description of the opportunity

The enterprise uses air heating systems in the production rooms The basic type of the equipment using thermal energy are calorifers operated on hot water or steam It was proven by world practice and experience that the systems currently used at the plant are not efficient, if there are available spare production areas and the operation is in one shift There is no system for automatic support of the temperature in the rooms during the working hours

Taking into account availability at the plant of natural gas, it is proposed to install on Production Ground #2 in some rooms and areas gas-fired heating systems The suggested systems have a set of advantages as compared to the traditional ones

- Typical saving in natural gas is 45 to 50 %,
- Placing the heaters above the heated objects and the opportunity to heat some zones locally if it is required by the processing
- Quick reaching the required temperature value in the heated zone and the possibility to switch on automatic control system for the days-off and for the week-ends
- Decreasing the number of places with "draughts" and provision of comfortable working conditions for the personnel
- Easy installation and maintenance

Calculation of the expected energy saving

A production room at Production Ground #2 with the area of 3,600 m² (36 m x 100 m)

1 The specific consumption of thermal energy for heating 1 m² of the area per year (the average indicator for the production rooms) is - 0 4 Gcal/m²
2 The area of the room is - 3,600 m²
3 Annual consumption of thermal energy for heating purposes
3,600 m² 0 4 Gcal/m² - 1,440 Gcal
4 Improvement of the efficiency when transferring on the infra-red system (due to the data from the manufacturing companies) - 50%
5 Yearly saving of thermal energy
1,440 Gcal 0 5 = 720 Gcal
6 The efficiency of the new plant (set due to the data from the manufacturing companies) - 95%
7 The clear efficiency of the boiler-house (set according to the testing data) - 87 5%
8 The calorific value of gas (data from the plant) - 8 090 kcal/m³
9 The yearly consumption of thermal energy for heating purposes - 720 Gcal
10 The yearly gas saving is

$$\frac{720{,}000{,}000}{8{,}090} \bullet (1 / 0\ 875 - 1/ 0\ 95) = 8\ 010\ m^3$$

Calculation of the yearly saving of costs

- The clear cost of 1 Gcal of thermal energy (data from the plant) - USD 15

- Saving of costs on the thermal energy
  720 Gcal USD 15 = USD 10,800
- 1,000 m^3 of gas cost USD 80
- Gas saving 8 010 m^3 USD 80 per 1,000 m^3 = USD 640
- The total yearly savings USD 10,800 + USD 640 = USD 11,440

Commissioning costs

There is proposed to use infra-red heaters of high intensity produced by *Schwank* company or similar operated on natural gas of 1 5 to 3 0 kPa

To provide the required thermal load 21 heaters are proposed to be installed, the capacity of each is 15 kW, they should be arranged in 3 rows 7 heaters with in each row

1 The price of one heater (from the price-list) - USD 430
2 The cost of the equipment USD 430 21 = USD 9,030
3 The costs of the designing, installing and adjusting works (set) - USD 10,000
4 The total costs USD 9,030 + USD 10,000 = USD 19,030

The simple payback period USD 19,030 USD 11,440 = 1 7 years ≅ 20 months

The proposal will be paid back after two heating seasons

ECO - 7 Steam electric power generating plant

Description of the opportunity

Steam boilers in the boiler-house generate thermal energy from 11 to 12-barg of saturated steam in accordance with the requirements of the manufacturing plant The steam using equipment at the plant operates on saturated steam with the pressure of up to 3 5 barg In the boiler-house the pressure is decreased from 12 to 4 barg by means of a reduction plant

In 1997 the boiler-house produced about 44,000 Gcal of thermal energy or 66,000 tonnes of steam with the pressure of 11 barg If the number of the working hours is 7,500 hours per year, the average production capacity of the boiler-house is about 8 8 tonnes of steam per hour Steam is produced in winter period by *DKVR-20/13* boiler having the capacity of 8 to 16 t/h, in summer time that is done by *DKVR-10/13* boiler with the capacity of 4 to 8 t/h

Decreasing the steam pressure in the reduction plant is a non-recovered energy loss

It is proposed to use the energy of the steam pressure reduction in the boiler-house for independent generation of electric power For that there is proposed, in parallel with the reducing plant, to use a steam electric power generating plant of *PVM-250-EG*

The electric power generating plant will decrease the steam pressure from 12 barg to 3 5 - 4 0 barg while providing the following specifications

- the electric power transferred into the distribution network at the plant - 175 kW (the maximum power is 250 kW)
- voltage - 380 V
- frequency - 50 Hz
- the specific flow rate of steam - 4 4 t/h
- the life time till capital repair - 40,000 hours

The proposed measure will allow the enterprise to generate in the boiler-house electric power with the capacity of 175 kW per hour and approximately decrease the electric power costs by 6 per cent

Calculation of the yearly energy saving

1 Yearly number of working hours for the electric power generating plant (set) - 5,000 hours
2 The amount of the electric power generated per year
175 kW 5,000 hours = 875,000 kW h

Calculation of the yearly saving of energy resources costs

1 1 kW h of electric power costs USD 0 04 (the data from the plant)
2 Saving of the costs by decreasing electric power consumption form the network of the regional electric power supply system
875,000 kW h USD 0 04 - USD 35,000

Commissioning costs

1 The cost of manufacture and installation of one plant due to the data from the manufacturing company is USD 62,500
2 The costs on the ancillary equipment (set) - USD 5,000
3 The overhead costs - USD 1,000
4 The total costs USD 62,500 + USD 5,000 + USD 1,000 = USD 68,500

The simple payback period is USD 68,500 USD 35,000 = 1 96 years ≈ 23 months

ECO - 8 Transfer of *NO-136* melting furnaces on natural gas

Description of the opportunity

At the plant for melting the secondary aluminum they use electric melting furnaces of *NO-136*-type that were designed for melting 180 kg of aluminum (the total number of the furnaces is 73, 29 are in operation) According to the data from the plant, one melting requires 205 kW h of electric power or 0 176 Gcal of thermal energy Melting of metal by converting electric energy into thermal requires noticeable financial costs, as 1 Gcal of heat received from electric energy costs USD 42, while if burning natural gas it costs USD 10

Taking into account the fact of availability at the plant of natural gas, it is proposed to perform modernization of the melting furnaces of *NO-136*-type to use natural gas

Calculation of the required amount of natural gas

The input data

initial temperature - 20°C,
melting temperature for aluminum - 660°C,
aluminum casting temperature - 750°C,
the specific thermal capacity of aluminum - 0 896 kJ/kg°C,
the specific thermal capacity of the melted aluminum - 385 2 kJ/kg,
the specific thermal capacity of the aluminum overheating - 1 02 kJ/kg°C

Aluminum is melted in three phases heating to the melting point (660°C), melting, then overheating to the casting temperature

The required amount of heat is as follows

for heating $Q_1 = 180 \quad 0\ 896 \quad (660 - 20) = 103{,}219$ kJ,
for melting $Q_2 = 385\ 2 \quad 180 = 69{,}336$ kJ,
for overheating $Q_3 = 180 \quad 1\ 02 \quad (750 - 660) = 16{,}524$ kJ

The total amount of heat is $Q = Q_1 + Q_2 + Q_3 = 189{,}079$ kJ

The required amount of natural gas at the gas calorific value (due to the data from the plant)
$Q^{oper}_{lower} = 8{,}090$ kcal/m^3 = 33,873 kJ/m^3

$$V = Q/\ Q^{oper}_{lower} = 189{,}079 / 33{,}873 = 5\ 58 \text{ m}^3$$

At the efficiency of the crucible furnace $\eta = 0\ 4$ to $0\ 5$ (40 to 50 per cent) the total need in natural gas is

$$V = V/\eta = 5\ 58/0\ 45 = 12\ 4 \text{ m}^3 \approx 13 \text{ m}^3$$

With taking into account a 30% margin, we will set the maximum consumption of natural gas for melting of 180 kg of aluminum will be $13 \text{ m}^3 \times 1\ 3 = 17 \text{ m}^3$

It is proposed to use a gas consuming aggregate with injection gas burners with a system of pipelines and blocking and regulating fixture and with the maximum gas supply not lower than 20 m^3/h Such an aggregate includes the following a crucible cast of pig iron taken from the existing furnace, the furnace case and space, the injection gas burners, the outlet drawing exhaust fan, gas pipelines arrangement scheme, instrumentation and control equipment and automatic systems

Calculation of yearly savings of costs

- 1,000 m^3 of natural gas - USD 80,
- The cost of the natural gas for one melting 17 m^3 USD 80 = USD 1 36
- 1 kW h of electric power cost USD 0 04
- 1 kW h of the electric power for one melting 205 kW h USD 0 04 = USD 8 20
- Saving with one melting USD 8 2 - USD 1 36 = USD 6 84
- The average number of meltings of aluminium for one furnace per year (set) 440 (10 to 12 meltings per week)
- The average number of the operated furnaces per year (set as 70% of the total number) - 39
- The total yearly saving USD 6 84 440 39 = USD 117,400

Commissioning costs

1 Costs of redesigning of one furnace (approximately) - USD 2,250
2 The number of furnaces to be rebuilt (set as 70% of the total number) - 55 furnaces
3 The total costs USD 2,550 55 = USD 140,250

The simple payback period USD 140,250 / USD 117,400 = 1 2 years ≈ 14 months

APPENDIX B MEASURED AND COLLECTED DATA

"Scheduling" of the operation mode at *DKVR 20/13 #1*

on March 24 and 25, 1998

DKVR 20/13 Boiler #1 (after the boiler)	*DKVR-20/13* Boiler #1 (before the exhaust fan)	*DKVR 20/13* Boiler #1 (with simultaneous burning mazut before the exhaust fan
BACHARACH MODEL CA300NSX ********** COMBUSTION ANALYZER	BACHARACH MODEL CA300NSX ********** COMBUSTION ANALYZER	BACHARACH MODEL CA300NSX ********** COMBUSTION ANALYZER
ID _____	ID _____	ID _____
SER NO YCO 513	SER NO YCO 513	SER NO YCO 513
TIME 10 10	TIME 11 38	TIME 11 30
DATE 24, 03, 98	DATE 24, 03, 98	DATE 25, 03, 98
FUEL NATURAL GAS	FUEL NATURAL GAS	FUEL NATURAL GAS
PRIMRY TEMP <C> 30	PRIMRY TEMP <C> 3	PRIMRY TEMP <C> 3
STACK TEMP <C> 308	STACK TEMP <C> 144	STACK TEMP <C> 118
% OXYGEN 8,3	% OXYGEN 9,6	% OXYGEN 8,5
% EXCESS AIR 60	% EXCESS AIR 77	% EXCESS AIR 62
% CARBON - DIOXIDE 7,1	% CARBON - DIOXIDE 6,3	% CARBON - DIOXIDE 6,9
PPM CARBON - MONOXIDE 2	PPM CARBON - MONOXIDE 3	PPM CARBON - MONOXIDE 4
PPM NOX 75	PPM NOX 67	PPM NOX 401
PPM SULFUR - DIOXIDE 0	PPM SULFUR - DIOXIDE 0	PPM SULFUR - DIOXIDE 25
% EFFICIENCY 83,0	% EFFICIENCY 90,6	% EFFICIENCY 92,9
% STACK LOSS 17,0	% STACK LOSS 9,4	% STACK LOSS 7,1
TEST PERFORMED BY	TEST PERFORMED BY	TEST PERFORMED BY

APPENDIX C PHOTOGRAPHS OF THE FACILITY

Фото 1 Административный корпус **Photo1 Administrative building**

Фото 2 Безмуфельный агрегат **Photo 2 Muffle-free aggregate**

Фото 3 Электроплавильная печь **Photo 3 Electric melting furnace**

Фото 4 Определение степени загрузки электродвигателей
Photo 4 Determination of the electric motors loading

APPENDIX D MEASUREMENT UNITS

MEASUREMENT UNITS

barg - atmosphere gauge
BTU - British thermal unit
^{0}C - degrees Celcius
cm^2 - centimeter squared
^{0}F - degrees Fahrenheit
g - gram
Gcal - gigacalorie
GJ - gigajoule
h - hour
kcal - kilocalorie
kg - kilogram
kgf - kilogram-force
kV - kilovolt
kV-A - kilovolt-ampere
kW - kilowatt
kW h - kilowatt hour
Lm - lumen
m - meter
m^2 - meter squared
m^3 - meter cubed
min - minute
MJ - megajoule
mm H2O - millimeters of water column
MW - megawatt
t - tonne
t/h - tonnes per hour
W - watt

APPENDIX E ABBREVIATIONS

ABBREVIATIONS

CCD - condensate contamination determination
ECO - energy conservation opportunity
ESCO - energy saving company
hrn - hrivnia (Ukrainian currency)
Fig - figure
NPP - nuclear power plant
tel - telephone
VAT - value-added tax
US - United States
USAID - United States Agency of International Development