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Delivery Order #30
Industrial Energy Efficiency - Ukraine
April 1998

REPORT
ON ENERGY AUDIT
AT Joint-Stock Company
Machine-Building Production Association *"ORION"*,
ODESA City, UKRAINE

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FOREWORD

As part of Delivery Order #30, Industrial Energy Efficiency - Ukraine, the U S Agency for International Development (USAID) sponsored energy efficiency audits at **24** industrial plants that met the criteria and were approved by USAID

Each facility was evaluated based on selection criteria (approved by USAID) for the selection of target plants, which included the long term economic viability of the plant, its financial conditions, its export revenues, its current production capacity ratio, the potential energy savings, the extent of replicability to similar industries, and its access as a demonstration facility

This report includes the findings of the energy audit performed by ***Burns & Roe Enterprise, Inc*** at the Joint-Stock Company **Machine-Building Production Association "*ORION*"** in the city of Odesa

1 EXECUTIVE SUMMARY

1 1 Introduction

As part of Delivery Order No 30, Industrial Energy Efficiency - Ukraine, the U S Agency for International Development (USAID) sponsored energy efficiency audits at 24 industrial plants that met the criteria and were approved by USAID 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 report details the findings of Burns and Roe Enterprises, Inc , energy audit performed at Machine-Building Production Association "ORION", located in Odesa, Ukraine The Joint-Stock Company "Machine-Building Production Association ***ORION*** (JSC MBPA ***ORION***) is modern enterprise and is one of the largest in its field in Ukraine

The project team consisting of two representatives of the American company **Burns and Roe Enterprise, Inc** , energy management experts Mr Viktor Svistunov and Mr Vladimir Prokopenko, performed the energy audit during April 20 - 25, 1998 trip to the site Having fulfilled its objectives, the project team prepared the following report

For budgetary reasons the audit was restricted to one week Therefore it was necessary to focus the energy audit on more promising areas of the plant Hence, the audit is based on what we really managed to do in a week Though the audit already includes many recommendations for the plant management, it is recommended to make a complete energy audit of the entire plant We hope that the plant management will invite the specialists trained within the framework of this project, to continue the work, to obtain a full picture of energy consumption at the plant and to making a full list of opportunities to improve the energy consumption at the plant

1 2 Principal findings

1 The share of electric power consumption in the plant energy costs is ***61*** per cent The boiler-house uses ***65*** per cent of the natural gas while the thermal equipment consumes another ***30*** per cent These users represent the main opportunities for energy conservation In the net cost of the production 3 4 per cent are from the energy costs

2 As expected, the audit group found many attractive opportunities for improvement of energy efficiency at the current prices When the energy prices were ***20*** to ***30*** times lower, energy efficiency improvements were uneconomical Today energy efficiency improvements make sense, but they are difficult for accomplishment due to exorbitant interest rates and distortions in economic incentives caused by the bartering system and mutual non-payments

3 Absence of energy metering on the level of separate workshops hinders energy conservation and introduction of an energy management system

4 A significant source of energy saving is an improvement in natural gas utilization via improved combustion at the boiler houses, as well as via steam traps, improved thermal insulation of the steam, condensate, and hot water pipes

5 Reduction in energy consumption can be received by improving the efficiency of ventilation system, heat supply system, compressed air system, and by using more efficient light sources

1 3 Recommendations

Table 1 1 (see the next page) lists the energy conservation opportunities (ECOs) identified for the facility, as well as estimated energy savings and cost savings and the simple payback periods The majority of the opportunities have the simple payback period of one year or less For

example, **ECO #1** - "Establishment of energy management system" will enable regular work aimed at energy saving and creation of energy management department The latter will be responsible for controlling and analyzing the energy consumption at the plant, as well as for development of recommendations and a reconstruction plant or for improvement of any system that can lead to energy savings

To assist improvements in energy efficiency in energy usage, USAID is contributing energy auditing equipment to the plant This equipment consists of portable instrumentation that will enable the plant to implement an energy management system

ECO #2 "Improvement of the boiler combustion efficiency" optimization of natural gas combustion in the boiler, with the help of a portable combustion analyzer, will improve the combustion efficiency and, as the result, will reduce gas consumption

ECO #3 "Installation of steam traps in the steam utilizing systems" will decrease steam consumption without worsening operation of the equipment and at the same time will improve the efficiency of using its thermal energy in the local sewage systems and in the heating and ventilation systems

ECO #4 "Thermal insulation of steam and hot water pipes" will reduce heat losses on the sections with the total length of ***898*** m

ECO #5 suggests hating the work places by efficient infra-red gas heaters instead of the air heating the whole space in an almost empty workshop This can decrease the consumption of natural gas by ***50***%

ECO #6 "Automatic metering of energy consumption" will provide a real picture of energy consumption at this plant, support the energy saving initiatives, provide the true figures for the energy consumption by the plant units functioning as business units

ECO #7 "Automatic control of the reactive power compensation" will improve compensation from $tg\phi_1 = 0\ 7666$ to $tg\phi_2 = 0\ 23$ and thus can provide saving of ***77,500*** kW h per year

ECO #8 by introduction of ***104*** efficient light sources instead of the ***DRL-400*** and ***DRL-250***-type lamps and the incandescent lamps for the outside lightning, improved reliability and decreased power consumption should result

ECOs #9, 10 Monitoring of the insulation, temperature of the coolant, and utilization of installed capacities will eliminate wasteful operational modes and will decreasing waste of fuel and energy resources

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Table 1 1

List of energy conservation opportunities

ECO #	Description	Electric power saving, kW h x 10^3	Saving of natural gas, m^3 x 10^3, that of mazut, tonne	Water saving, m^3 x 10^3	Yearly saving, USD (prices for 1997)	Measure cost, USD, (prices for 1997)	Simple payback period, year(s)
1	Establishment of energy management system	89 25	25 5	1 3	9 096	11 300	1 24
2	Improvement of the boiler combustion efficiency		64 0 (5 5)		7,010	6,500	0 93
3	Installation of steam traps in the steam utilization systems		23 7 (2 05)		2,598	6,870	2 6
4	Thermal insulation of steam and hot water pipes		86 5		8 569	11 979	1 4
5	Heating the work places by efficient infra red gas fired heaters		130		12 870	23 170	1 8
6	Automatic metering of energy consumption	89 25	25 5	1 3	28,250	56 000	1 9
7	Automatic control of the reactive power compensation	77 5			2 200	5 000	2 3
8	Utilization of highly efficient lighting sources	50 77			3,128	3,230	1 1
9	Monitoring of the boiler equipment operation and of the temperature operation mode of the thermal energy consuming equipment		10 2 (0 88)		1 118	1,000	0 89
10	Monitoring and optimization of the capacity of the electric equipment	17 7			1,093	1 000	0 91
	Total	**324 5**	**365 4 (8 43)**	**2 6**	**75,932**	**126,049**	

The capital investments of *US $8,500* aimed at improvement of the energy efficiency with the short-term payback periods (**ECO # 2, 9, 10**) will lead to the yearly saving US $*9,220* as well as to decreasing the electric power consumption by US $*17,700* kW h and that of natural gas by *74,200* m^3, that of fuel oil (mazut) - by *6 38* tonnes The capital investments of US $*117,549* aimed at improvement of the energy efficiency with the payback period of more than one year (**ECO #1, 3 - 8**) will give the yearly saving of US $*66,712*, as well as to reduction of electric power consumption by *306,800* kW, that of natural gas - by *291,200* , of mazut for furnaces - by *2* tonnes

The total decrease in the electric power consumption will be *324,500* kW h (*29 6* per cent of the consumption for 1997), and that in the consumption of natural gas will be *365,400* m^3 (*71 6* per cent of the consumption for 1997), that of the liquid oil - *8 43* tonnes (*19 2* percent)

The total decrease in the amount of emissions into the atmosphere of harmful substances resulting from implementation of the proposed measures will be *5 64* tonnes, including there in particular *1 43* tonnes of solid particles, *0 2* tonne of carbon oxide, *0 8* tonnes of nitrogen oxides and *3 21* tonnes of sulfur oxides

The said energy conservation opportunities (ECOs) can be implemented at other industrial enterprises too, or, in other words, they can be considered standard settlements of standard problems

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 MBPA *"Orion'*, 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 JSC MBPA *"Orion* are about *3 4* per cent of the total cost of the products produced

Currently, at the JSC MBPA *"Orion"*, 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 These 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 MBPA *"Orion'* 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 *5* per cent 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

1 5 Implementation

Implementation of the energy saving opportunities given in Table 1 1 is planned for the future, after completion of this project

2 GENERAL BACKGROUND

Name of the enterprise – Joint-Stock Company

***"Machine Building Production Association* ORION"**

Board Chairman, Director General – Mr Nikolai Stepanovich **Kushchak**

Technical Director – Mr Ivan Dmitriyevich **Kolomiyets**

Tel (0482) 22 - 43 - 39 /61 - 03 - 04 /61 - 29 - 06

Fax (0482) 22 - 38 - 42, 61 - 78 - 52

Address AO MPO *"ORION '*, 6, Harkavyi Str , Odesa City, Ukraine, 270098

2 1 History of the plant

"Machine Building Production Association *Orion*" was set up in 1973 by amalgamation of three plants Mechanical Plant after Khvorostin, Plant after Petrovsky and *Molmash* Plant In 1995 the amalgamation was reset into a joint-stock company, ***100%*** of the shares are owned by the state in the body of the Ministry of Industrial Policy till the end of the privatization The JSC MBPA *Orion* includes the following branches Production and Commercial Firm *"Orion-Service"*, Production and Commercial Firm *"Orion-Perspektiva"*, Health Care Combined Facility *"Orion'*

The Association is specializing on manufacture compressors for refrigerators, freezers and consumers' goods

JSC MBPA *Orion* physically is located on three production grounds within the border of the city of Odesa, its profile is manufacture of compressors for household refrigerators, compressors for refrigerators and freezers, compressors for the transport refrigerators, flasks of aluminum for food products, products of eatable aluminum and of a wide assortment of consumers' goods The management scheme for JSC MBPC "*Orion*" is shown in Fig 2 1

Production areas can be described with the following figures

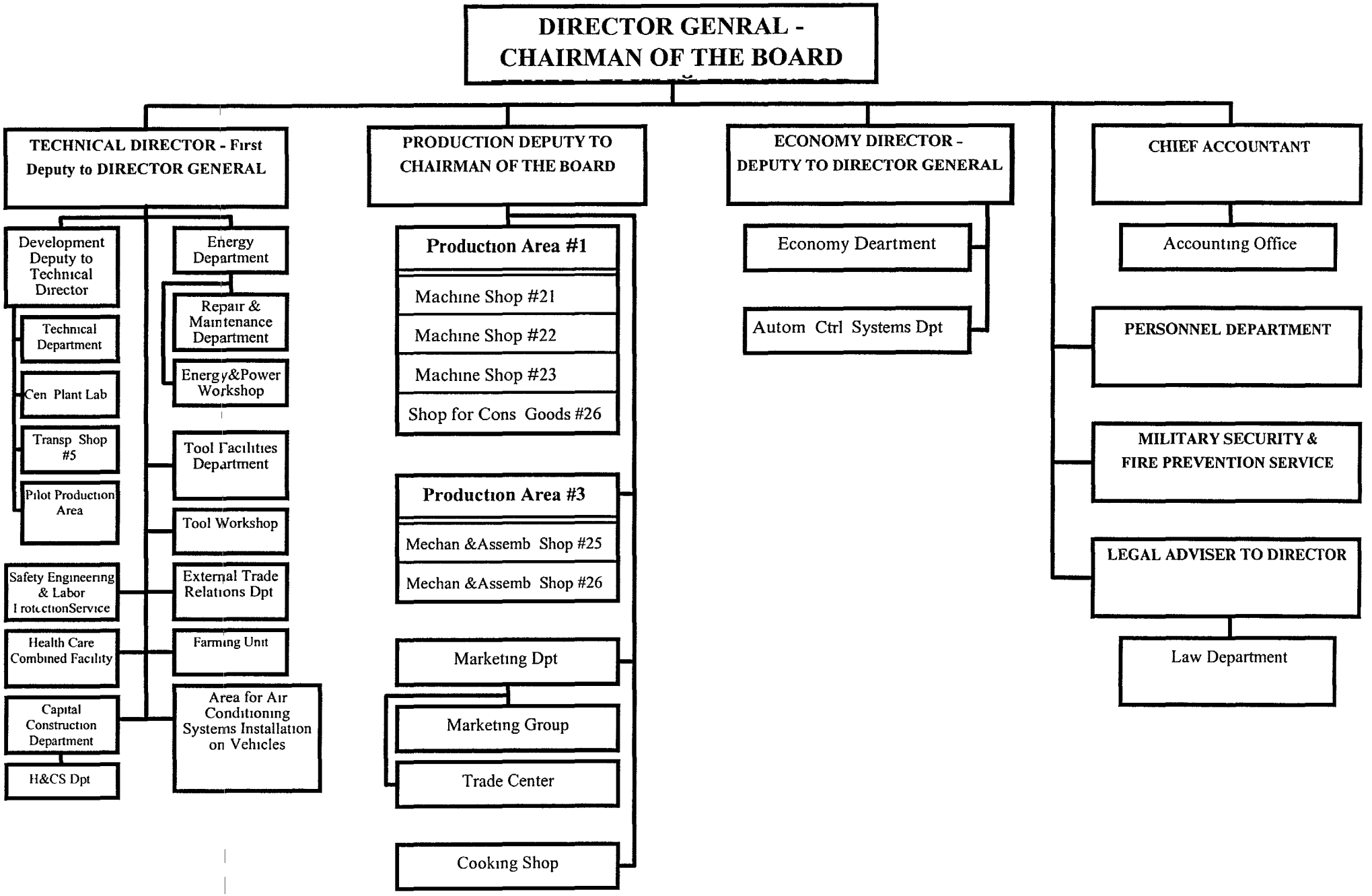
total area of the plant territory – ***6 73*** ha,

total area under the buildings and structures – ***50,400*** m^2,

among that for the non-production buildings – ***39 4*** m^2, including there

- **Production #1**
  - the area of the territory – ***2 3*** ha,
  - the area under the buildings and structures – ***22,000*** m^2
- **Production #2**
  - the area of the territory – ***1 24*** ha,
  - the area under the buildings and structures – ***6,630*** m^2

Fig 2 1 Management scheme for JSC MBPA PA"*ORION*"



- **Production #3**
  - the area of the territory – ***3 19*** ha,
  - the total area of under the buildings and constructions – ***21,500*** m^2

At the plant there were worked out investment projects aimed at modernization of the current production facilities, as well as organization of manufacturing of about ***1*** million of new advanced types of compressors There are ***22,000*** m^2 of spare areas that were provided not long ago and are prepared (about ***70*** per cent) for receiving equipment

2 2 Manufactured products

At JSC *"Orion '* they manufacture the following

- compressors for domestic refrigerators and freezers of *KShG-II, KhRL5L120, KhShV-6,65,*
- compressors for the car and other vehicle conditioners (production on the license of "***SEIKO-SEIKI***" Company, Japan),
- air conditioning systems in the cars and vehicles,
- intergally extended flasks for keeping and transporting food products,
- a wide assordment of consumers goods (utensils of aluminium)

The products manufactured by the association meets the requirements of the international standards The basic competitors are

- on the domestic market - JSC *"Nord"*, the city of Donetsk,
- on the foreign market *"Sanyo"*, Japan, *"Zanussi"*, Italy, *"Danfoss"*, Denmark, enterprises in Russia and Belarus

The coolant used in he refrigerator compressors is ozone-friendly

The average number of the personnel at the plant is about ***806*** persons

2 3 Significance of sector to economy

There is only one enterprise in Ukraine that is similar in the profile to that of JSC *"Orion"* - this is JSC *"Nord '* in Donetsk City, which accounts for why JSC MBPA *"Orion"* has an important significance as a supplier of refrigerator compressors for the domestic and transport refrigerating technology and for mobile system of air conditioning

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3 CURRENT STATUS OF PRODUCTION

3 1 Maximum calculated productivity

The designed capacity of the enterprise provided manufacture of products in process of 1997 for *57 2* million hrn , also including here as follows compressors for refrigerators and conditioners of *KShG-II* type - **440,000** units, of *KhRL*-5L120 – ***31,200*** units per year, flasks of aluminum of *F4-38*-type - ***1,520,000*** units

3 2 Real productivity 1997 against 1995 and 1996

During 1995 - 1997 the plant operated with an incomplete loading, as the former connections and cooperated supplied were broken So, in 1995 the loading of the production facilities was ***16 1***%, that in 1996 was ***30 6***%, that in 1997 was ***32 5***% The production volumes are shown in

Table 3 1

Table 3 1

Production volumes

Product	Measure unit	Production volumes 1995	1996	1997	Percentage in 1997 against that in 1995	1996
1 Compressors for domestic refrigerators	hrn x 10^6	3 6	5 9	5 9	164	100
	units x 10^3	39 7	65 0	65 0		
2 Compressors for vehicle conditioners	hrn x 10^6	0 3	0 3	0 7	233	233
	units x 10^3	1 7	1 7	4 0		
3 Flask for food products	hrn x 10^6	3 8	10 0	11 2	295	112
	units x 10^3	50 9	134	150		
4 Consumers goods	hrn x 10^6	1 5	1 3	0 8	53 3	61 51
Manufacture volume, total	hrn x 10^6	**9 2**	**17 5**	**18 6**	**202**	**106**

Analysis of the data from Table 3 1 shows that the production volume after the deep crisis of 1995, when the loading of the production facilities was only ***16 1***%, is gradually rising and in 1997 it was ***202***%, at that time the production volume of compressors for the typical refrigerators increased by ***164***%, that of compressors for vehicle compressors - by ***233***%, flasks for food products - by ***295***%

3 3 Prospects for development

The marketing, processing and technological services of the enterprise are engaged in the work aimed at the perspective development of the plant

Concerning the new technologies, relations are being made with the companies *"Danfoss* (Denmark), *Sanyo* , *"Seko-Seiki'*, *"Nisso'Ivai"* (Japan) At the plant there are worked out investment projects for modernization of the current operateable production facilities, as well as organization of manufacture of new types of compressors of the advanced technical designs, and

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also designing new refrigerator technology units on the basis of the produced now compressors (freezer-outs, concentrators, etc) There are under consideration proposals to set up joint-ventures with the companies *Zanussi* and *Danfoss*

Certain instability is contributed by the incomplete privatization of the plant, and in particular the uncertainty in determination of the future owner of the enterprise shares, *100%* of whose belong now to the state

3 4 Export vs domestic consumption

The Association provides supplies of products for both users in Ukraine, and on expert

The basic users of the products are the following ones

- compressors for the domestic refrigerators Ukraine – *70%*, Moldova – *10%*, CIS-countries – *20%*,
- compressors for vehicle conditioners Ukraine – *80%*, Russia – *20%*,
- flasks of aluminum – Ukraine, Tunisia, Arabic Emirates

Production volumes in Ukraine and for exporting are given in Table 3 2

Table 3 2

Country-user	Unit	Объемы продаж		
		1995	1996	1997
Ukraine	USD x 10^6	3 84	5 76	5 74
Russia	USD x 10^6	1 3	1 4	1 9
Moldova	USD x 10^6	-	0 9	2 3
Foreign countries	USD x 10^6	1 26	0 24	0 26
Export vs Import in Ukraine	%	66 7	44 1	77 7

Analysis of the data from Table 3 2 and in Paragraph 3 2 shows that the association has got stable relations only on the foreign market of the CIS-states, the supplies tot he foreign market are not higher than *7 3%* of the production facilities of the association, however there is a slow but steady rise 1995 – *2 27%*, 1996 – *4 0%*, 1997 – *7 3%*

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4 FINANCIAL STATUS OF THE ENTERPRISE

4 1 Barter vs Currency operations

In the economic activities of JSC MBPA *"Orion"* barter operations are of significant portion

In 1996 they were *68 0%*, and that in 1997 was *24 0%*, which can be explained by the payment crisis in Ukraine

4 2 Viability of the enterprise

The basic financial results of the plant activities are given in Table 4 1 Their analysis shows that the balance profit of the plant in 1997 was minimal, while the net profit after paying taxes was in 1997 equal to zero In other words, the enterprise has no its own funds for development its facilities

Table 4 1

Basic ficiancial indicators

Characteristics	Values vs, years, UAH x 10^6		
	1995	1996	1997
1 Gross profit	9 4	17 7	18 9
2 VAT (20%)	1 3	2 8	2 5
3 Production costs	7 7	14 8	16 6
4 Balance profit	0 4	0 05	0 05
5 Net profit	0 3	0 04	-
6 Actual production costs	7 5	14 2	16 3

Certain estimation of the enterprise can be done by the viability indicators given in Table 4 2 , which have the critical values speaking of an instable financial status of the enterprise in the studied period

Table 4 2

Financial stability indicators

Показатель	1995	1996	1997
Profitability, %	5 2	0 3	–
Coefficient of Liquidity	1 02	0 993	1 13

The enterprise has from the previous year an indebtedness in the payment to the personnel and in that for the energy resources

The figures in Table 4 1 and 4 2 show that during 1995-1997 the total production volumes and, respectively, the gross production rose in 1996 against 1995 by *88 3%*, and against 1996 - by *6 8%* However, a low capacity factor for the production facilities accounts for a high level of conventionally constant expenses on keeping the non-used production funds and, as the consequence, for the rising of the expenses on production in 1995 by *92 2%* against that in 1997, and in 1996 - by *12 2%*, which leads to decreasing the profit and the profitability of the production facilities

The enterprise is actively working on extension of its sale market

5 ANNUAL ENERGY CONSUMPTION AND COSTS

5 1 Annual consumption, 1995-1997

At the JSC MBPA *"Orion"* the primary energy resources are used that are purchased from the local energy supplying organizations in form of electric power, natural gas and drinking water Thermal energy in form of saturated stream with the pressure of *3* kg/cm^2 is generated with the temperature of *132*°C by three boiler-houses of the plant that are equipped with boilers of DKVR--2,5/13 and DKVR-6,5/13 The yearly consumption and the energy costs are shown in Table 5 1 The electric power and natural gas consumptions are correspondingly *21 6*% and *66 8*% of the total energy consumption at the plant However, if the cost ration is concerned, the figures are somewhat different electric power - *60 6*%, natural gas - *25 1*%

Table 5 1

Total energy consumption and the energy costs due to the data for 1997

Energy resources	Yearly consumption,	Yearly consumption, Gcal	Percentage of the total consumption, %	Yearly costs, USD	Percentage of the yearly costs, %
Electric power	1,785,000 kW h	1,535	21 6	1,100,000	60 6
Natural gas	510,000 m^3	4,743	66 8	45,600	25 1
Mazut	44 tonnes	430	6 1	10,000	5 5
Water	26,000 m^3	390	5 5	16,000	8 8
Total	–	**7,098**	**100 0**	**181,000**	**100 0**

Fig 5 1, 5 2 shows the distribution of the costs and amounts of the consumed energy versus the energy sort for 1997 The monthly energy consumption is shown in Table 5 2 and Fig 5 3 and 5 4

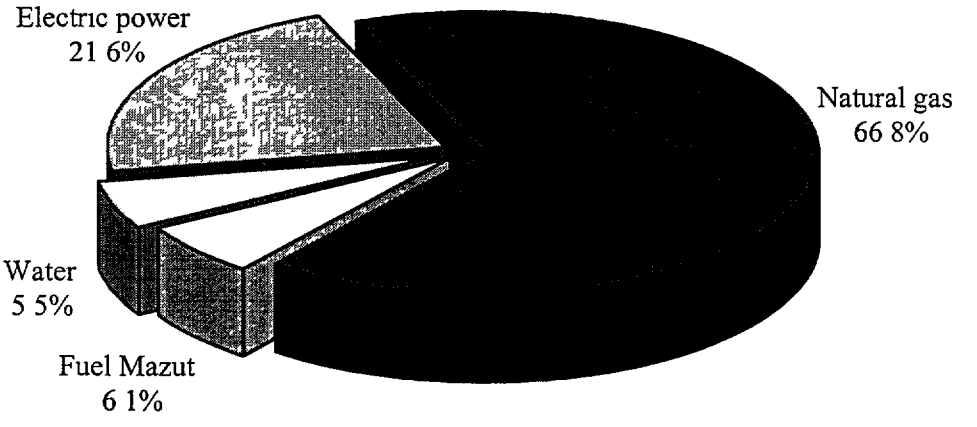

Fig 5 1 Distribution of energy resources for 1997

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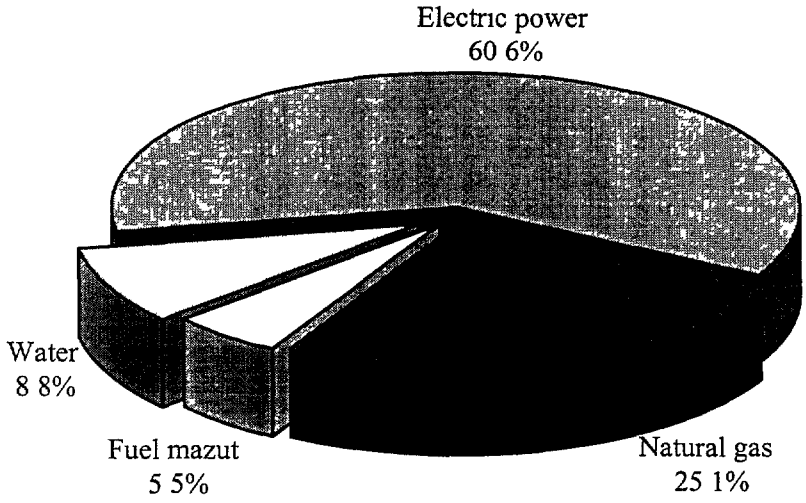

Fig 5 2 Distribution of costs on energy resources for 1997

Table 5 2

Electric power consumption at JSC MBPA *"Orion"* in 1997 for the production needs

Month	Electric power consumption, kW h x 10^3	Gas consumption, m^3 x 10^3
January	116	130
February	137 2	98
March	154 6	67
April	149	8
May	77 7	8
June	65 2	3,5
July	51	8
August	58 4	3,4
September	51 4	6
October	49 9	3
November	82 4	37
December	103 6	58
Total	**1,096,4**	**429,9**

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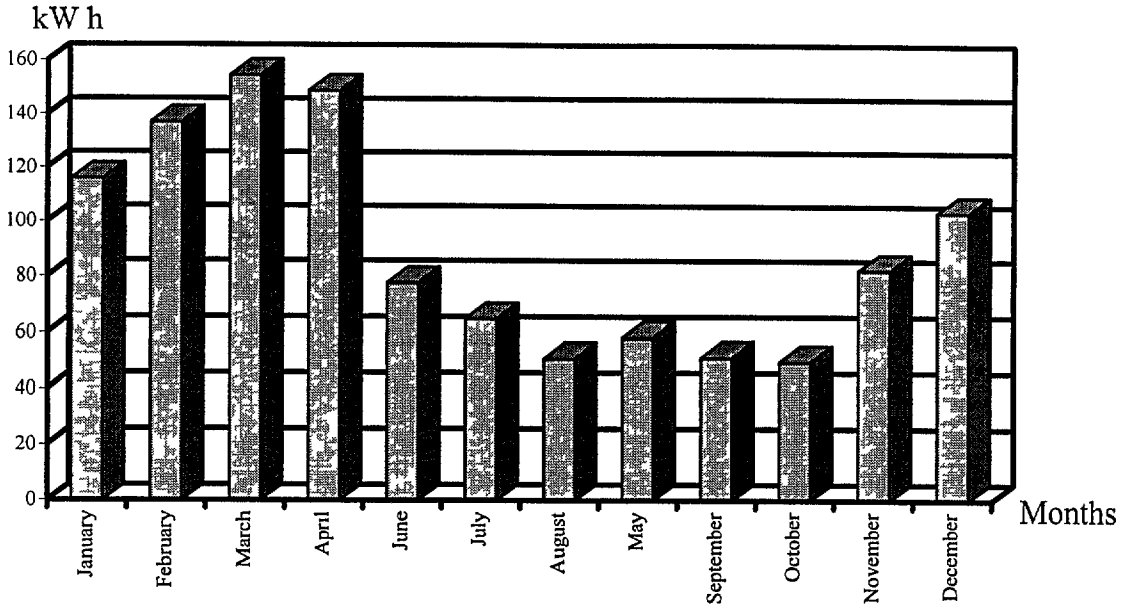

Fig 5 3 Consumption of electric power

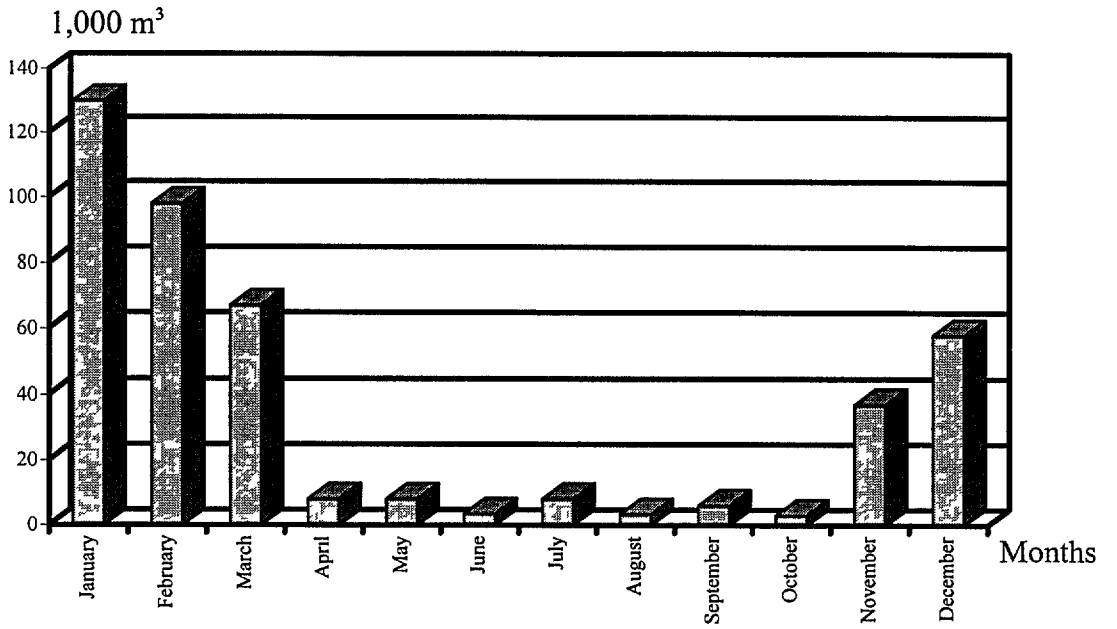

Fig 5 4 Consumption of gas

The total consumption of electric power in 1997 was ***1,785,000*** kW h, that of natural gas – ***510,000*** m³, of mazut – ***44 000*** m³, water - ***26,000*** m³ Varying in the electric power and natural gas consumptions is accounted for by decreasing of the heating loading and hot water supply in the summer period

5 2 Current energy and fuel prices

JSC MBPA *"Orion"* in 1997 paid for the energy resources US $***565,000*** The energy costs are about *3 5*% of all production costs That is why the measures aimed at energy saving can noticeably improve the financial indicators for the plant

The scheme of payment for electric power is a two-rate based tariff Once a year the plant makes a contract with an electric power supplying organization concerning the maximum active electric power consumption level per month according to the expected needs and it pays for the actual consumption that shall not exceed the maximum agreed limit If the actual consumption is above

the maximum agreed consumption limit, the consumption shall be paid for on the five-fold basis The contract price on the electric power for industries is *7 2* kopecks per kilowatt-hour (US $*0 036* per kW h), that for the non-industrial users is US $*0 047* per kW h, the tariff for the plant dwelling houses is US $*0 09* per kW h

There is also payment for the declared power that concerns the periods of the peak loads - from *8* to *10* hours in the morning and from *18* to *22* hours in the evening, its value is US $4 per

1 kW h Similarly *1* kVAr of the declared reactive power costs US $*0 1334* per *1* kVAr, that of the consumed reactive power is US $*0 00072* per *1* kW h

The average electric power cost, according to the data from the plant, was in 1997 US $*0 0616* per *1* kW h

Natural gas is provided to the plant from the main city gas supply line, and it is chiefly used to generate steam and hot water in the boiler-house There are gas meters at the gas distribution stations Gas consumption is paid for monthly on the basis of US $*99* per *1,000* m^3 since November 4, 1997 Mazut is supplied in cisterns for the price of US $*112 5* per *1* tonne

Cold water is provided to the plant through two flow-rate meters from the Odesa water supply system *Odesavodokanal* The price for water is US $ *0 815* per *1* m^3

5 3 Energy use profile

The production subdivisions of the plant consume the following sorts of energy

- electric power *~380/220* V, *50* Hz for electric drives, electric furnaces, dryers and lighting system,
- thermal energy in forma of saturated steam with the pressure of *2 5* kg/cm^2 to enable fulfillment of the processing operations concerning drying and washing the compressor parts, for heating purposes, ventilation and for hot water supply through the boiler-houses,,
- natural gas - for production of steam by the boiler-houses, for thermal processing in the plasma furnaces, for electric furnace for light soldering

Power supply for the plant is provided from the network of the State Joint-Stock Energy Company ***ODESAOBLENERGO*** through the transformers *6/0 4* kV with the total installed capacity of *6,320* kVA, the connected power of the transformers is *5,690* kkVA The installed capacity of the electric motors is *1,110* kW, the installed capacity of the electric devices for heating, drying and electric welding is *2,085* kW, out of those *670* are for the electric furnaces To compensate the reactive power there are cosine capacitors with the installed power of *1,527* kVAr The capacity of the lighting system is *651* kVA, including here *51* kVA of the external lighting system

One of the directions in using electric power is production of compressed air with the pressure of *16* and *6* kg/cm^2 Each production ground has its independent compressor station

There are the following types of compressors installed at the plant

VP-50/8 – the production capacity is capacity is $G = 50$ m^3/min , the pressure is $P = 8$ kg/cm^2, the capacity of the electric drive is $N = 315$ kW (*3* units),

VP-20/8 – $G = 20$ m^3/min , $P = 8$ kg/cm^2, $N = 125$ kW – *4* units,

VP-10/8 – $G = 10$ m^3/min, $P = 8$ kg/cm^2, $N = 22$ kW – *2* units,

VK-25EA – $G = 1,25$ m^3/min, $P = 25$ kg/cm^2, $N = 22$ kW – *1* unit,

2VT1-2,1/26M1 – $G = 2,1$ m^3/min $P = 26$ kg/cm^2, $N = 22$ kW – *1* unit,

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2VT1-1 8-23 – ***G = 1,8*** m³/min, ***P = 23*** kg/cm², ***N = 22*** kW – ***1*** unit,

The total installed capacity of the ventilation systems is ***483*** kW, the production capacity is ***829,181*** m³/hour

In 1997 electric power was used for the following purposes for the electric devices used in the processing operations(drying, heating) – ***574,000*** kW h, for the Electra drivers – ***1,195*** кkW h, the losses in the network are ***16,000*** kW h, the total consumption is ***1,785,000*** кkW h

The main sources of thermal energy at the plant are the steam boiler-houses placed on three production grounds where natural gas and mazut are used The installed capacity of the independent heat sources is ***13 76*** Gcal/h, including there also as follows

- **Production Ground #1**
  1) *DKVR-6 5-13*, the thermal heat production capacity is ***Q = 3 94*** Gcal/hour, the steam pressure is ***P = 6*** kg/cm², ***η = 90%***, the fuel used is natural gas,
  2) *DKVR-2 5-13*, ***Q = 1 43*** Gcal/hour, ***P = 6*** kg/cm², ***η = 90%***, the fuel used is natural gas,
- **Production Ground #2** – *DKVR-2,5-13*, ***Q = 1 38*** Gcal/hour, ***P = 6*** kg/cm², ***η = 90%***, the fuel used is natural gas – 2 units,
- **Production Ground #3** – *DKVR-2,5-13*, ***Q = 1 46*** Gcal/hour, ***P = 6*** kg/cm², ***η = 89%***, the fuel used is natural gas

The designed need for thermal energy is ***34,527*** Gcal per year, including here the following heating of the buildings – ***13,040*** Gcal (***38%***), hot water supply – ***1,140*** Gcal (***3%***), the processing needs – ***20,347*** Gcal (***59%***)

A lot of gas is used for the electric furnaces for light soldering of *KVP-60B*-type to sold components of copper at the temperature of ***1,150***°C (2 units) and the electric furnace of the chamber type - *SK-2,5-5,0-17/10* - for firing products of glass at the temperature of ***1,200***°C (1 unit), where natural gas is used as a restoring medium The gas is purified before being supplied into the furnace in the endogas generators of *EM-125M2*-type with the production capacity of ***4*** m³/hour at the pressure of ***0 05*** kg/cm² (3 units)

Water supply to the plant is provided from Odesa city water supply

The figures for production output during 1995-1997 are given in Table 3 1, the figures for energy consumptions versus the energy are given in Fig 5 5 to 5 7

At the plant there is no instrumental metering consumption of natural gas and thermal energy by each production area, workshop for each product manufactures, therefore there are no objective criteria to estimate the energy consumption in regard of the said items Currently these estimations are done by the economy department of the plant by means of calculation methods on the basis of the designed specific consumptions and production volumes of the manufactured products дукции The results of using the fuel and energy resources are reported in the special state statistic form *#11 мпт* "Report on the results of using fuel, thermal energy and electric power"

Years	Total consumption, tonnes of conventional fuel	] Including		
		Production of thermal energy	Other production needs	Use for the non-production needs
1995	2,320	1,581	19	150
1996	762 2	700	1	61 2
1997	649	494	144	11

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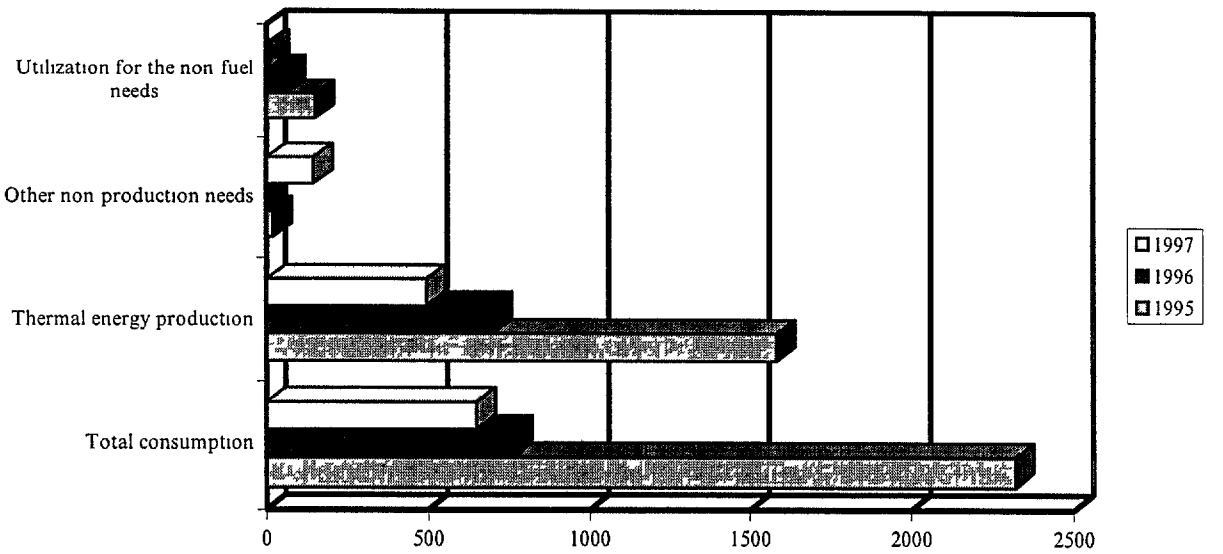
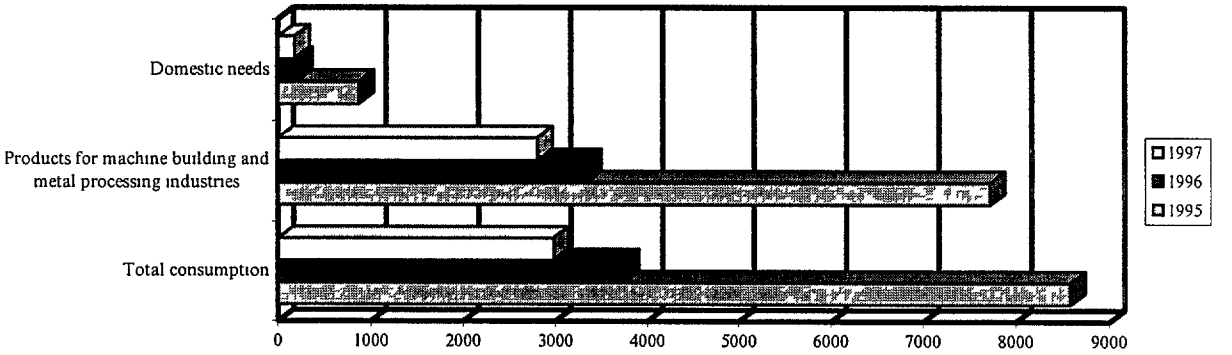


Tonnes of equivalent fuel

Fig 5 5 Natural gas consumption versus the sorts of products or sorts of works

Years	Total consumption, Gcal	Including	
		Products for machine building and metal processing industries	Domestic needs
1995	8,584	7,715	869
1996	3,738	3,335	203
1997	2,978	2,802	176



Years	Total consumption, kW h x 10^6	Including		
		Products for machine building and metal processing	Other production needs	Domestic needs
1995	2,743	2 053	67	623
1996	1852 8	1 352	63 8	437 8
1997	1 785	1 096	87	602

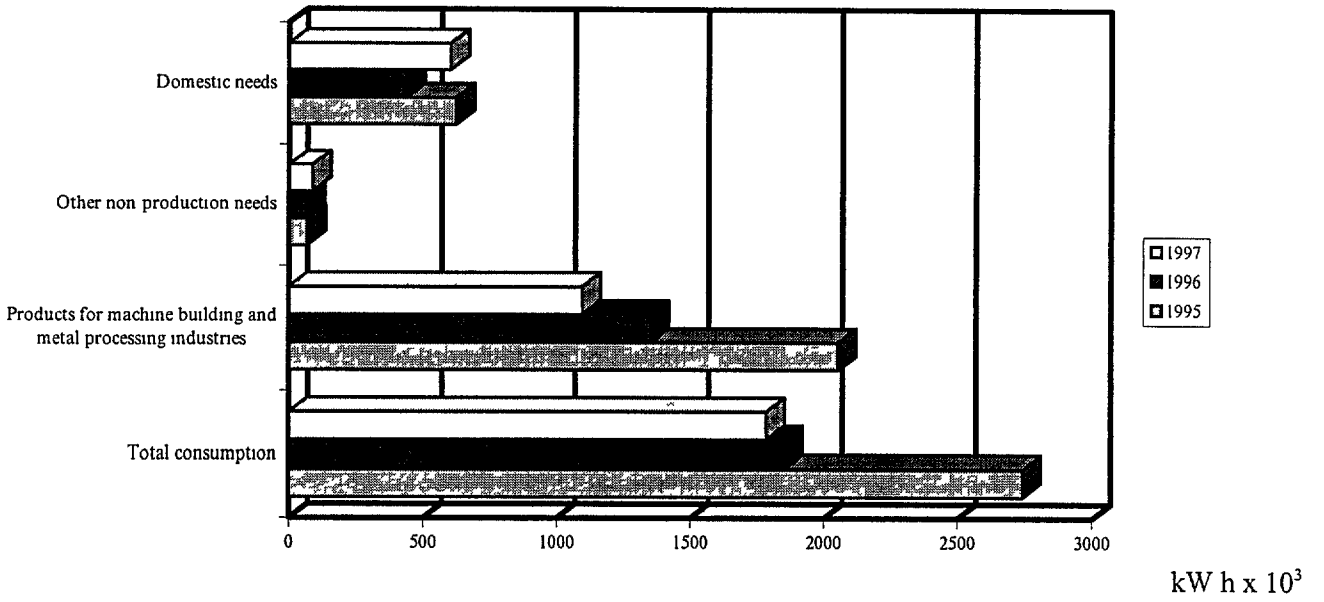


Fig 5 7 Consumption of electric power versus the sorts of products or sorts of works

Balances of energy resources consumption versus the production areas of the plant are shown in Fig 5 8 – 5 12, where it is seen that the largest **electric power** *consuming users* are the energy and power workshop – *17 3%*, the machine workshop – *13 44%*, the tool workshop #31 – *10 87%*, that in regard of **natural gas** the boilers in the power workshop – *89 4%*, that of **water** the power workshop – *50%*, the mechanics and assembly workshop #25 – *23%*

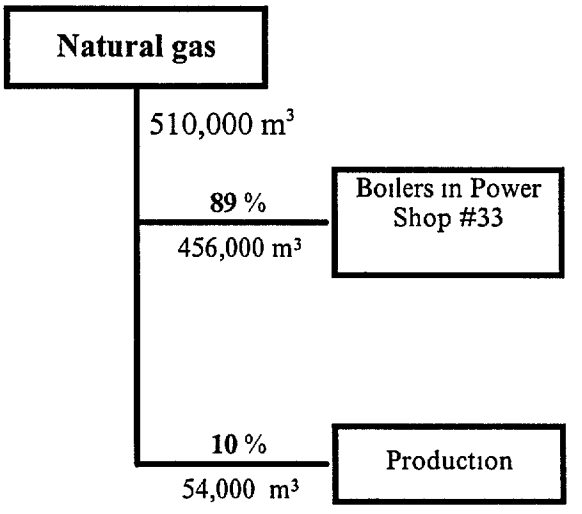


Fig 5 8 Balance of natural gas utilization at JSC MBPA *"Orion"* in 1997

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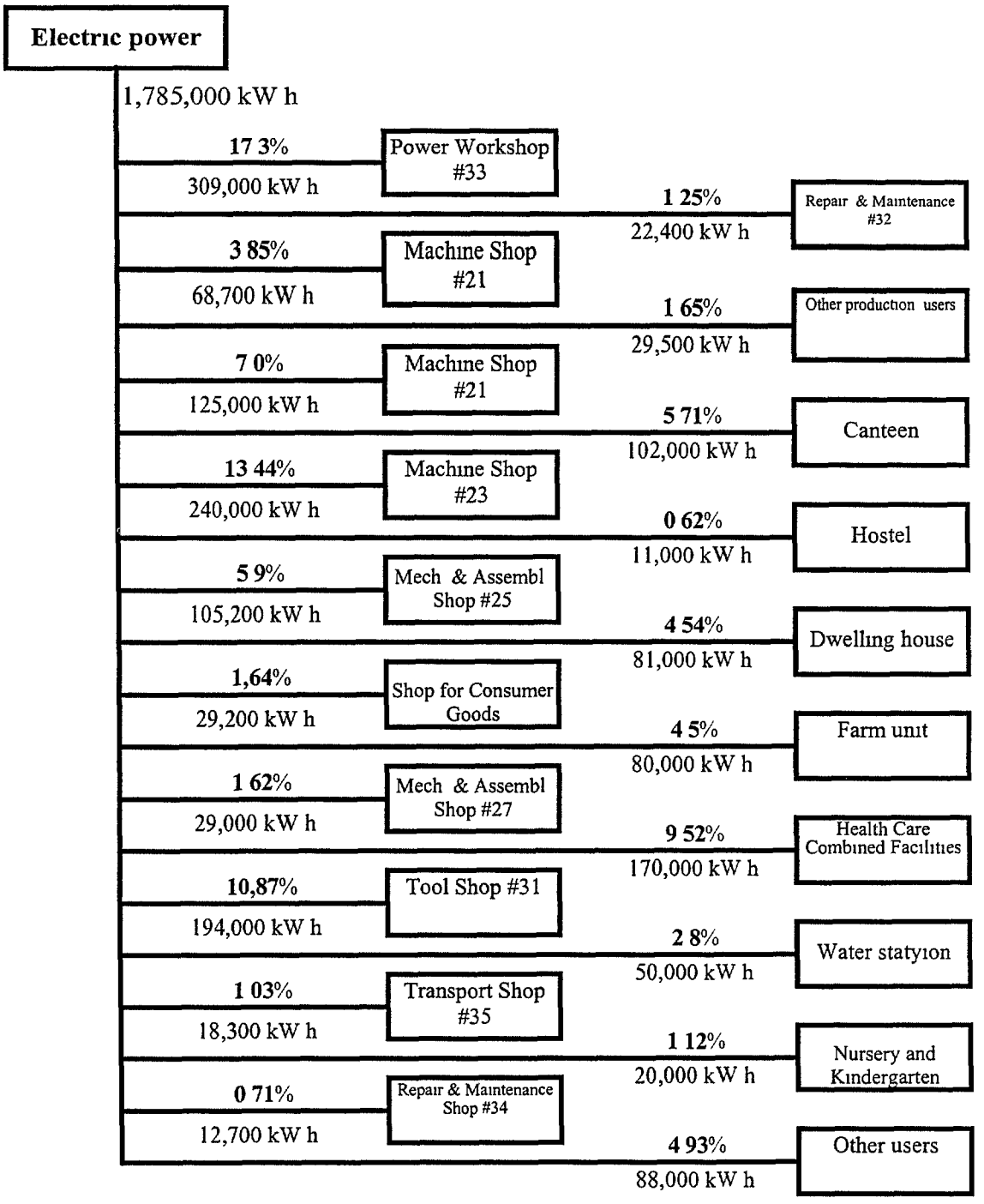

Fig 5 9 Balance of electric power utilization at JSC MBPA *"Orion"* in 1997

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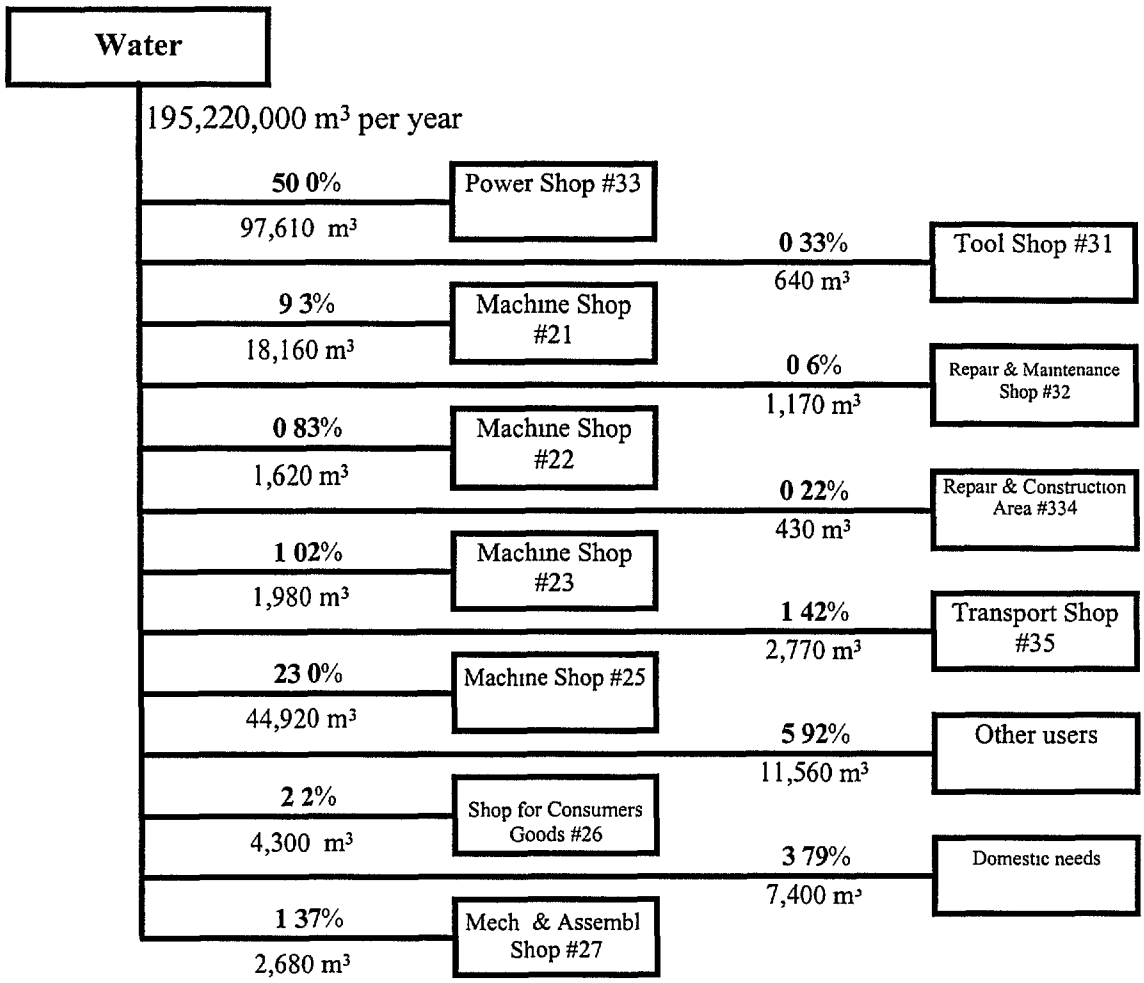

Fig 5 10 Balance of water utilization at JSC MBPA *"Orion"* in 1997

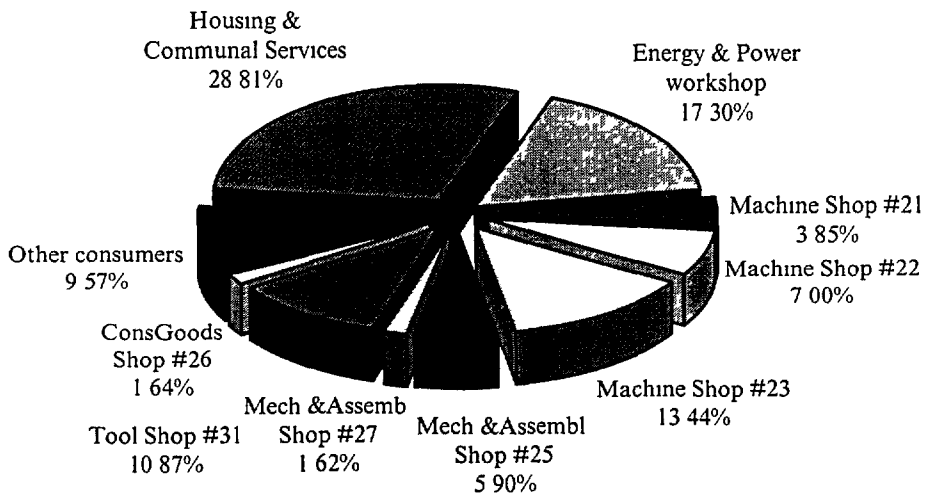

Fig 5 11 Distribution of electric power consumption at JSC MBPA *"Orion"* for 1997

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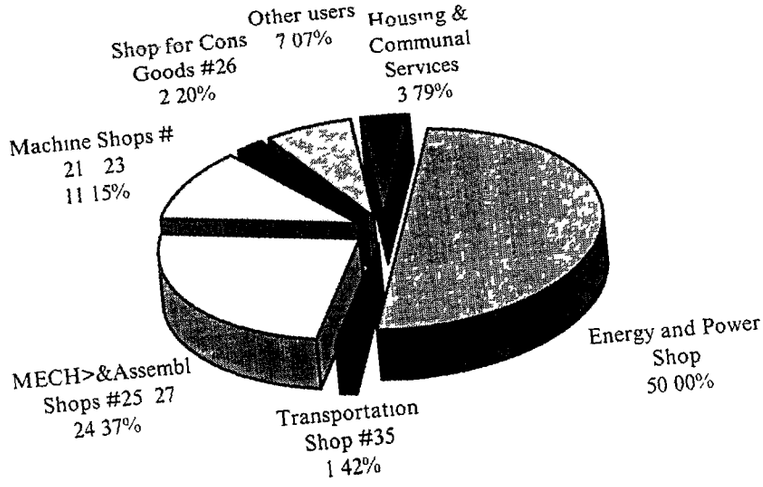

Fig 5 12 Distribution of water consumption at JSC MBPA *"Orion"* for 1997

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6 PREVIOUS ENERGY IMPROVEMENTS

Certain work is being carried out at the plant in regard of implementation of energy saving measures

- annually plans of measures aimed at saving fuel and energy resources are worked out,
- as the loading of the facilities has been reduced, there were worked out schedules of operating the equipment and heating and ventilation systems consuming a lot of energy? As well as the schedule of operating the production areas,
- the non-loaded power transformers were disconnected from the energy system,
- the majority of the steam ducts, condensate pipelines and hot water supply lines were insulated, the thermal insulation is regularly repaired,
- the operation of the air compressors was automatized, their switching-on is done due to the need in compressed air

The main problem that remains at the plant is absence of a system of organization of the works to provide efficient planning and organization of energy resources utilization and controlling of the energy consumption modes

The majority of the energy saving measures were put into practice on the basis of absence of a perspective plan of implementing energy conservation, the scopes of works were determined by the allocated financing opportunities

That accounts for why a lot of energy conservation opportunities remained not implemented

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7 ENERGY AUDIT

Analysis of the data of the efficiency of utilization by the plant of the fuel-and-energy resources that were given in Section 5 in this report, as well as the study of the actual utilization of the energy resources served as a basis for working out proposals concerning energy conservation opportunities (ECOs) considered below They allow to decrease consumption of electric power by ***324,500*** kW h (29 6 per cent of the total consumption in 1997), that of natural gas by ***365,400*** m^3 (71 6 per cent), that of fuel mazut - by 8 43 tonnes (19 2 per cent) It must be noted that the plant has got other energy conservation opportunities too which cannot be considered currently economically reasonable, as the production facilities in the country are loaded very little

The proposed ECOs can be implemented at other enterprises, and they can be considered like standard settlements of a standard problem

ECO #1 Establishment of energy management system

The main instrument in reduction of energy consumption and improvement of the efficiency of the energy utilization at industrial enterprises is energy management Energy management is a management system based on carrying out typical measurements and checkings and providing operation of a plant that leads to consumption of the amount of energy really required for this processing only

By introduction of energy management one can gain a more detailed picture of energy utilization, which allows to compare the energy consumption levels with those at other enterprises, in order to estimate more precisely the projects aimed at energy saving that are planning for their implementation at the given plant

It is proposed to introduce at the plant an energy management system in its full scope Implementation of this proposal will enable to decrease consumption of energy resources by *5%*

According to the data for 1997, the plant consumes during a year ***1,785,000*** kW h of electric power, ***510,000*** m^3 of natural gas, ***44*** tonnes of mazut, ***26,000*** m^3 of water The world practice confirms that in case of introduction of an energy management system there is guaranteed decreasing of consumption of energy resources by *5%* Energy resources saving will be as follows

1) Electric power	– ***89,250*** kW h
2) Gas	– ***25,500*** m^3
3) Water	– ***1,300*** m^3
Project implementation costs	– US $***11,300***
Yearly saving of costs	– S_{costs} = US $***9,096***
Simple payback period for the project is	– ***1 24*** years

For the details in regard of this proposal see Appendix A, ECO #1

ECO #2 Improvement of the boiler combustion efficiency

To meets the needs in thermal energy, ***5*** types of boilers are used at the plant in ***3*** boiler-houses 1 unit of *DKVR*-6,5-13 type and 4 units of *DKVR-2,5-13* type To operate the said boilers operation mode charts were worked out, however no automatic control of gas-to-air-ratio due to the load change has not been provided The indicator of the air flow-rate is controlled

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periodically by the pressure of the forced air, while that for the gas is done by the pressure before the burners, which in the conditions of the uncontrolled air infiltrations does not allow to speak about an optimal burning process The optimal burning process is set by the operator die to his subjective consideration of the color of the flame in the boiler-house

It is proposed to provide for the operation service at the plant boiler-house a combustion analyzer of "*ENERAC-2000*" or *BACHARACH* type and to put on the operators to check regularly the combustion conditions, which will ensure making adjustment and maintenance works in due time, improvement of the boiler combustion efficiency and saving of natural gas

Gas saving in natural units	$S_{gas\ nat.\ units} = G\ \ b = 64{,}000$ m^3
Mazut saving in natural units	$S_{mazut} = 5\ 5$ tonnes
Yearly saving of energy costs	S_{osts} = US $7,010 per year
Commissioning costs	$Commis_{costs}$ = US $6,500
Simple payback period is	*0.93* years

ECO #3 Installation of steam traps in the steam utilization systems

At the plant steam with the pressure of *2 5* kg/cm^2 is used for the heating needs, hot water supply and processing purposes As it was mentioned in Section 5 3, the designed needs for the said purposes are correspondingly as follows *13,040, 1,140* and *20,350* Gcal However, for the incomplete loading of the production facilities of the plant, the factual heat consumption was in 1997 only *2,802* Gcal Besides, condensate is provided back only from Boiler Shop #22 Condensate in relation of the other systems is discharged into the canalization

As the audit results showed, the steam using equipment and the steam heating system are not equipped with steam traps, so the flash steam with the condensate with the temperature of *105 - 110*°C are discharged into the canalization

To improve the efficiency of the steam utilization system the system for steam supply into the shops must be transferred from steam on water, all the steam using equipment must be provided with steam traps, condensate must be returned into the boiler-house Nowadays, the most loaded steam utilizing equipment is as follows the electric plating equipment in Workshop #21, the plant for drying stators (14 chambers) and *3* washing machines in Workshop #23, as well as the boilers in Workshops # 21, 22, 25, 27 and 31

It is proposed to install for the said equipment steam traps that will increase the efficiency of operation of the steam using equipment by *10* to *15* per cent and even more

The yearly saving of thermal energy will be *130 4* Gcal (*23,700* m^3 of natural gas, *2 05* tonnes of mazut)

Yearly saving of the costs on thermal energy	- S_{costs} = US $2,598 per year
Commissioning costs	- $Commis_{costs}$ = US $6,870
Simple payback period is	- *2 6* years

ECO #4 Thermal insulation of steam and hot water pipes

The carried our analysis of the steam distribution has shown that some steam pipelines and its branches, as well as the tube ducts of the hot water supply system had no insulation

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It is proposed to insulate completely the steam pipe network and the network of the hot water supply system

Yearly saving will be S_{yearly} = *583* Gcal/year, which is equal to *86,500* m^3 of natural gas

Yearly costs saving	–	S_{costs} = US $*8,569* per year
Commissioning costs	–	$Commis_{costs}$ = US $*11,979*
Simple payback period	–	*1 4* year

ECO #5 Provision of infra-red heating system

They use air-and-register heating of Workshops # 22 (Machine Workshop), 23 (Mechanics and Assembling Workshop) and 31 (Tool Workshop) The maximum calculated consumption of heat in Workshop #22 is *1,218* Gcal per year, in Workshop #23 - *1,407* Gcal per year, in Workshop # 31 - *789* Gcal per year According to the data from the plant, the said purposes bring to consumption of *1,500* Gcal of heat In the conditions of an incomplete loading of the production facilities some of the heat is used non-reasonably, as heating of the whole building is provided, not only that of the working places

It is proposed to install in Workshops #22, 23 and 31, over the working places, infra-red heating systems instead of the currently existing heating systems

Saving of natural gas will be	–	S_{gas} = *130,000* m^3
Yearly saving of coasts of energy resources	–	S_{costs}= US $*12,870*
Costs of commissioning the heaters	–	$Commis_{costs}$ = US $*23,170*
Simple payback period is	–	*1 8* years

ECO #6 Automatic metering of energy consumption

The plant consumes several sorts of energy resources electric power, gas, steam, compresses air, technical and drinking water

Electric power is supplied to the plant by three cable inputs with the voltage of *6* V At the production ground the electric power is distributed through *6/0 4*-kV substations with the total capacity of *6,320* kVA Commercial metering of the electric power consumption is done on the inputs The readings of the meters are made manually Technical metering at the plant is not provided

A detailed study of the plant showed that each subdivision of the plant calculates the amount of its independent consumption of steam, electric power, gas, compressed air, cold and hot water is done on the basis of the standard rates and actual volumes of the manufacture products No instrumental metering of energy resources consumption is available at the plant

It is proposed to automatize the commercial and technical metering of energy consumption with the help of the instruments for controlling and metering consumption of energy resources of *ITEK* type manufactured by *"Enerhiya"* Research Institute, Kyiv City These metrological instruments are certified in Ukraine and used for continuous or regular measurements/registration of physical parameters

To implement the measure there is planned to organize commercial metering of electric power consumption in *6* points, commercial metering of gas consumption - in *1* point, that of drinking water - in *2* points, of steam - in *2* points

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Technical metering of electric power will be provided in *20* points, technical metering of drinking water – in *10* points, that of water for the processing needs - in *16* points, hot water - in *8* points, gas – in *3* points

Experience prompts that, after introduction of an independent energy metering system and introduction of a system for checking and planning the energy resources costs, the expected saving will be lower than *5* per cent

Saving of natural gas will be ***25,500*** m^3, that of electric power - ***89,250*** kW h, water - ***1,300*** m^3

Yearly saving of costs	– S_{costs} =US $\$28,250$
Commissioning costs	– $Commis_{costs}$ = US $\$56,000$
Simple payback period is	– *1 9* years

ECO #7 Automatic control of the reactive power compensation

They use at the plant some devices for the reactive power compensation with the total capacity of *1,527* kVAr that are not equipped with systems for automatic controlling the connected power, which results in the average weighted power coefficient in the power supply system to the plant being significantly lower than the value set in the project ($\cos\varphi = 0\ 975$ on the *0 4*-kV side with taking into account the compensations), and it is equal, according to the data gained by the plant while making monthly loading plots for 1997, $\cos\varphi = 0\ 652$ The low value for the power factor results in losses of electric power Besides, as it was shown by the results of measurements, the re-compensation brings rising of the voltage to ***237 0 to 246 7*** V, which leads to an abrupt reduction of the life time of the lighting devices

It is proposed to equip the devices for the reactive power compensation with an automatic control system

Yearly saving of electric power will be	– $S_{el.\ poweras}$ = *77,500* kW h
Yearly saving of the costs	– S_{costs}= US $\$2,200$ per year
Commissioning costs	– $Commis_{costs}$ = US $\$5,000$
Simple payback period is	– *2 3* years

ECO #8 Utilization of highly efficient light sources

The system for the external lighting of the territory of the plant includes *50* ***SPZR***-type illuminants with the mercury high-pressure lamps of *DRL-400* type (*16* units) and ***DRL-250***-type (*42* units) A part of the territory of the plant adjoining to the production buildings is lit with ordinary incandescent lamps with the capacity of *500* W The system of the internal lighting of Production Ground #1 includes *1,463* illuminants with lamps having the total installed capacity of *161* kW, that for Production Ground #2 - *530* illuminants with lamps having the total capacity of *64 6* kW, that for Production Ground #3 - *780* illuminants with lamps having the total capacity of *73 2* kW The total installed capacity of the lighting fixture for the internal lighting in the production rooms is *298 8* kW, including here *17* lamps of DRL-400 type (*6 8* kW) and *123* lamps of DRL-250 type (*30 75* kW)

It is proposed a project of replacing the mercury lamps of ***DRL-400*** lamps used for the external lighting of the territory of the plant and for the internal lighting system in the workshops with the sodium high-pressure lamps of ***DNaT-250-3*** type, while the lamps of ***DRL-250*** type to be replaced with the lamps of ***DNaT-100-3*** types, and remain the current illuminants fixture but replacing the stating-up devices The sodium high-pressure lamps of ***DNaT-250-3*** type produced

in the City of Poltava, Ukraine, have a longer life time – ***12,000*** hours at the illuminant flux of ***25,000*** Lm, while respectively for ***DNaT-100-3*** those are ***6,000*** hours and ***9,000*** Lm

Yearly saving of electric power will be – S_{power} = ***50,770*** kW h
Commissioning costs – **Commis$_{costs}$** = US $***3,230***

For the systems of the external and internal lighting the yearly saving of the costs will be S_{costs} = US $***3,128*** per year
Simple payback period – ***1 1*** years

ECO #9 Monitoring of operation of the boiler equipment and of the temperature mode of the heat utilization equipment

The plant has a branched steam-and-condensate system, hot water supply system as well as a heating system, but with that there are practically absent continuously working pressure gauges and thermometers monitoring the operation mode of the equipment It is impossible to carry out analysis of the efficiency of operation of the heat using plants, calculate the specific energy consumption, to identify in due time equipment faults

It is proposed to introduce at the plant a portable infra-red thermometer of ***"Reynger ST6"*** type, which will enable to carry out monitoring of the heat using equipment, to provide a regular control (***1 - 2*** times a week) the efficiency of its operation and to undertake in due time measures aimed at decreasing losses of thermal energy Taking into account the state of the thermal using equipment and the level of its operation the expected improvement of the efficiency of heat utilization will be ***2 0%***

The expected heat saving is ***56*** Gcal, which is ***10,200*** m^3 of natural gas and ***0 88*** tonne of mazut

Yearly saving of the energy resources costs - S_{costs}= US $***1,118***

The cost of a portable infra-red thermometer of ***"Reynger ST6"*** type is US $$***1,000***
Simple payback period is - ***0 89*** year ≈ ***11*** months

ECO #10 Monitoring and optimization of the capacity of the electric power using plants

According the data for 1997, the basic manufacture consume about ***66*** per cent of the total amount of the electric power consumed by the plant, which is ***1,183,000*** kW h per year that cost US $***730,000***

One of the basic consumers of electric power is electric drives for the processing, pumping and ventilation equipment

In the process of operation of the plant, if motors failed, they were replaced without taking into account the nominally required capacity As it was shown by the measurements of the power capacity of the electric equipment, providing the current loading of the production facilities, there is its underloading, and the potential of the electric motors is used only to ***30*** - ***40*** per cent

It is proposed to introduce at the plant operational control of the power that is actually consumed by the electric equipment (and primarily by the electric drives) using for that a set of portable instruments and by measuring the power factor Implementation of the proposed measure will allow to carry out monitoring of the actual loading of the electric equipment, analyze its efficiency and organize its planned replacement with more efficient one Implementation of this proposal will permit to save mot less than ***1 5*** per cent of electric power that is used for the processing needs during a year

Expected saving of electric power - *17,700* kW h

Decreasing of the costs of electric power - US **$1,093**

The cost of one set of portable instruments of ***"2000 A wattprobe"*** and ***"Power Factor Meter, TIF 2300"***, with taking into account the overhead and transportation costs, is US $***1,000***

<u>Simple payback period is</u> - ***0 91*** year (≈ ***11*** months)

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8 ENVIRONMENTAL IMPACTS OF THE RECOMMENDATIONS

The most efficient way to decrease the amount of harmful emissions into the atmosphere is by decreasing the amount of the used fuel and electric power, so implementation of the proposed recommendations is important from the ecological point of view too Chapter 7 contains calculations made to prove possibility of opportunities to save thermal energy, natural gas and electric power

Taking into consideration that the plant provides meeting its needs for thermal energy from its own boiler-house, its energy saving is in saving natural gas

The saving of natural gas after implementation of the proposed measures will be as follows

ECO #1 – $S_{1_g} = 25,500$ m³/year,
ECO #2 – $S_{2_g} = 64,000$ m³/year,
ECO #3 – $S_{3_g} = 23,700$ m³/year,
ECO #4 – $S_{4_g} = 86,500$ m³/year,
ECO #5 – $S_{7_g} = 130,000$ m³/year,
ECO #6 – $S_{8_g} = 25,500$ m³/year,
ECO #9 – $S_{9_g} = 10,200$ m³/year,

The total saving of natural gas will be

$$S_{totalgas} = S_{1_g} + S_{2_g} + S_{3_g} + S_{4_g} + S_{5g} + S_{6g} + S_{9_g} =$$

$$= 25,500 + 64,000 + 23,700 + 86,500 + 130,000 + 25,500 + 10,200 = 365,400 \text{ m}^3\text{/year}$$

When natural gas is burned, the carbon oxide CO and nitrogen oxides NO_x are emitted into the atmosphere

We will determine the value of the prevented emissions into the atmosphere using the results of the study of the boiler (Appendix B), they showed that the emissions are as follows

- for the carbon oxide

$$M_{CO_B} = h_{CO_B} \; S_{total} = 0\ 116 \;\; 365,400 = 42,4 \text{ kg},$$

- for nitrogen oxides

$$M_{NOx_B} = h_{NOx_B} \; S_{total} = 0\ 234 \;\; 365\ 4 = 354 \text{ kg},$$

where h_{CO}, h_{NOx} – specific emissions for the carbon oxide and nitrogen oxides respectively, kg/1,000 m³

The results of the calculations are given in Table 8 1

The saving of electric power at the plant providing implementation of the measures will be as follows

ECO #1 – $W_1 = 89,250$ kW h,
ECO #6 – $W_6 = 89,250$ kW h,
ECO #7 – $W_7 = 377,500$ kW h,
ECO #8 – $W_8 = 50,770$ kW h,
ECO #10 – $W_{10} = 17,700$ kW h,

The total saving of electric power will be

$$W_{total} = W_1 + W_6 + W_7 + W_8 + W_{10} =$$

$$= 89,250 + 89,250 + 77,500 + 50,770 + 17,700 = 324,500 \text{ kW h/yr}$$

According to the data from the Ministry of Energy of Ukraine for 1996, the average amounts of emissions to produce 1,000 kW h of electric power were as follows

emissions of hard particles – 4 4 kg,

carbon oxide CO – 0 5 kg,

nitrogen oxides NO_x – 2 2 kg,

sulfur dioxide SO_2 – 9 9 kg

The results of the calculations for the amounts of prevented emissions of harmful substances into the atmosphere and the electric power saving are given in Table 8 1

Table 8 1

Summing up figures for the amounts of the prevented emissions of harmful substances into the atmosphere as the result of implementation of the proposed measures

Sort of emission	**Emission of natural gas**	**Decreasing the amount of the emission versus the electric power saving**	**Total decreasing during a year**
Hard particles, tonne		1 43	1 43
Carbon oxide, tonne	0 042	0 16	0 2
Nitrogen oxides, tonne	0 085	0 71	0 8
Sulfur oxides, tonne		3 21	3 21
Total, tonne	0 13	5 51	5 64

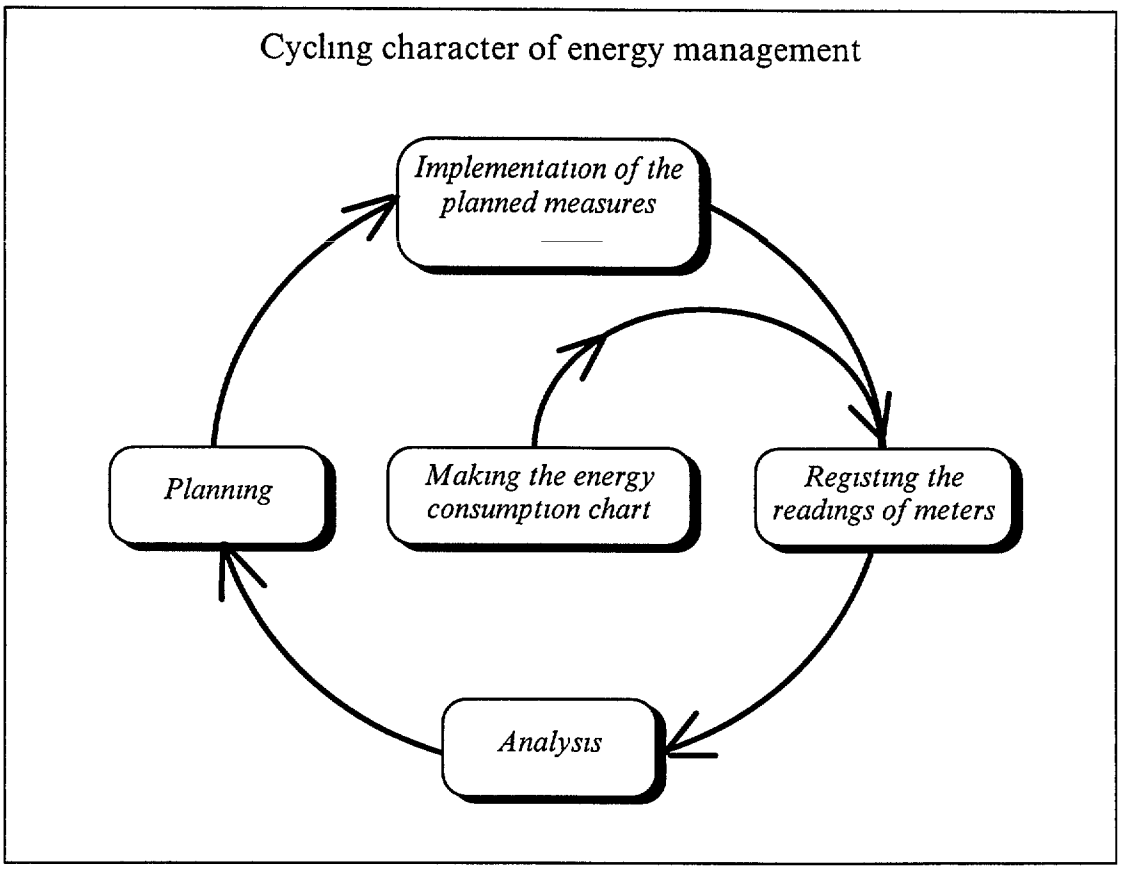
So, implementation of the proposed measures will bring to decreasing the emissions of hard particles into the atmosphere by ***5 64*** tonnes, which, of course, will be of the positive effect on the ecological environment in the City of Odesa

APPENDIX A ENERGY CONSERVATION OPPORTUNITIES (ECO'S)

ECO #1 ESTABLISHMENT OF ENERGY MANAGEMENT SYSTEM

Description of the opportunity

The main instrument to decrease energy consumption and improve the efficiency of energy utilization at industrial enterprises is energy management Energy management is a system of controlling based on making typical measurements and checks that provides such operation of an enterprise when it consumes the amount of energy just exactly required for its production needs Energy management is an instrument of managing the enterprise that provides a continuous study and, therefore, some knowledge of the distribution and the conditions at the plant as well as that of the optimal utilization of energy resources for both the production needs, and for the heating and some other non-production purposes



By introduction of energy management a more detailed picture of the energy use can be received, which will allow to make a comparison of the consumption levels with consumption levels at other enterprises to estimate as exactly as possible the energy saving projects that are to be implemented at a given plant

Energy management starts from appointment by the administration of the plant on the post of the energy manager of a person to be responsible for implementation of the energy management at the plant The principal duties of the energy manager are as follows

- Participation in making the chart of the energy consumption at the plant (probably, in cooperation with an involved consultant - an energy auditor)
- Collecting data in regard of consumption of fuel and energy resources using energy consumption meters and other measuring instrumentation
- Making a plan of installment of ancillary meters and measuring instrumentation
- Collection of data in regard of the streams of the raw materials, fuel and energy resources as well as of the finished products

- Calculation of the key data concerning improvement of the energy utilization efficiency - on the whole and in regard of some certain sorts of production
- Introduction of new technologies at the current and new energy systems aiming at improvement of the energy efficiency of the production facilities
- The energy manager shall maintain its own awareness of the current energy policy and of the related aspects (for example, of a new taxation law, valid limits in respect of energy consumption, subsidies, the environment protection, etc)

It is proposed to implement at the plant an energy management system in its full scope Implementation of this proposal will provide an opportunity to decrease energy resources consumption by *5* per cent

Implementation of energy management at the plant requires development and introduction of a system for metering the electric power consumption with deciphering the readings of the electric power meters in relation of all the transformer substations in the time scale The existing commercial metering allows to check the total electric power consumption, while the internal consumers can be controlled only from time to time

It is necessary to develop a system for metering consumption of all sorts of energy resources using up-to-date computer-based technology, which will allow to estimate the dynamics in energy consumption when manufacturing products and to work out recommendations aimed at saving energy resources

Calculation of the yearly energy saving

According to the data for 1997, the plant consumes yearly ***1,785,000*** kW h of electric power, ***510,000*** m^3 of fuel (gas), ***44*** tonnes of mazut, ***26,000*** m^3 of fuel (gas) The world experience and practice prove that introduction of energy management guarantees decreasing of consumption of energy resources by *5* per cent Saving of energy resources will be as follows

1) electric power – $1{,}785{,}000 \times 0\ 05 = 89{,}250$ kW h
2) gas – $510{,}000 \times 0\ 05 = 25{,}500$ m^3
3) water – $26{,}000 \times 0\ 05 = 1{,}300$ m^3

Calculation of the yearly saving of costs

1 If *1* kW h of electric power costs US $*0 0616,* then the saving of the electric power costs will be

$$89{,}250 \times 0\ 0616 = \text{US } \$5{,}500$$

2 If *1* m^3 of gas costs US $*0 099,* saving of the costs will be

$$25{,}500 \times 0\ 099 = \text{US } \$2{,}530$$

3 If *1* m^3 of water costs US $*0 82*, then saving of the costs will be

$$1{,}300 \times 0\ 82 = \text{US } \$1\ 066$$

The TOTAL saving of the energy costs is

$$5{,}500 + 2{,}530 + 1{,}066 = \text{US } \$9{,}096$$

Commissioning costs

The world practice shows that the costs of implementation of energy management are planned and they are *2* to *5* per cent of the cost of the enrage resources It includes the costs of improvement of the systems for metering the energy resources consumption, the payment of the

plant energy manager, expenses on involvement of a consulting company providing services in the energy saving field, this company is expected to do the following

- review of the stream of energy at the plant,
- energy consumption chart,
- energy consumption balance,

as well as

- putting forward proposals aimed at improvement energy efficiency,
- implementation of an energy management system,
- help in organization of purchasing energy efficient equipment

If the yearly energy costs (due to data for 1997) are US $\$565,000$, the total costs of implementation of energy management will be

$$565,000 \times 0\ 02 \cong \text{US } \$11,300$$

Estimation of the simple payback period

Project implementation costs – US $\$11,300$

Yearly saving of costs – US $\$9\ 096$

Simple payback period is – $11\ 300\ /\ 9\ 096 = 1\ 24$ years

ECO #2 IMPROVEMENT OF BOILER COMBUSTION EFFICIENCY

Description of the opportunity

To meets the needs in thermal energy, *5* types of boilers are used at the plant in *3* boiler-houses 1 unit of *DKVR-6 5-13* type and 4 units of *DKVR-2,5-13* type To operate the said boilers operation mode charts were worked out, however no automatic control of gas-to-air-ratio due to the load change has not been provided The indicator of the air flow-rate is controlled periodically by the pressure of the forced air, while that for the gas is done by the pressure before the burners, which in the conditions of the uncontrolled air infiltrations does not allow to speak about an optimal burning process The optimal burning process is set by the operator die to his subjective consideration of the color of the flame in the boiler-house

The above said is proved by the results of measurements of the indicators of the natural gas combustion in the boiler of *DKVR-6,5-13* type that were carried out by means of a combustion analyzer of ***BACHARACH*** type (Appendix B) As it was seen from the results of the measurements, the content of oxygen on the duct for the exhaust gases from the boiler was *16 6* to *20 8*%, the coefficient of the exceeding air was *3 76* to *4 52*, the temperature of the exhaust gases after the boiler was *124*°C, that before the exhaust fan was equal to *30*°C, the combustion efficiency was *83 5*%, (without taking into consideration the temperature of the blown air)

It is proposed to provide for the operation service at the plant boiler-house a combustion analyzer of "*ENERAC-2000*" or ***BACHARACH*** type and to put on the operators to check regularly the combustion conditions, which will ensure making adjustment and maintenance works in due time, improvement of the boiler combustion efficiency and saving of natural gas

Calculation of the yearly energy saving

According to the data given in the form of the statistical reporting #11 *мтп* "Report on the results of fuel, thermal energy and electric power utilization", in 1997 the plant produced

2,802 Gcal for the industrial needs and *176* Gcal for the domestic and housing needs, with that the factual consumption of fuel was $G = 649$ tonnes of the conventional fuel or *510,000* m³ of natural gas and *44* tonnes of mazut According to the manufacturer's certificate for *DKVR-6,5-13 DKVR-2,5-13* that are equipped with economizers shall have the efficiency $\eta = 92\%$ and the consumption of the conventional fuel equal to *155 12* kg of the conventional fuel per *1* Gcal

The results of the measurements showed that the average value of the boiler efficiency is $\eta_{Baver} = 77\%$ at the factual specific consumption of *185 6* kg of the conventional fuel

Implementation of the said measure will decrease the specific standard rate of the consumption by $b \approx 12{,}5\%$ and it makes it equal to *162 34* kg of the conventional fuel, increase the average weighted value of the boiler efficiency up to *88*%

Saving in the natural units will be

for gas – $S_{gas} = G \quad b = 510 \quad 0\ 125 = 64{,}000$ m³

for mazut – $S_{mazut} = 44 \quad 0\ 125 = 5\ 5$ tonnes

Calculation of the yearly saving of costs

Saving of costs in terms of money, if *1,000* m³ cost US $*99,* and *1* tonne of mazut costs US $ *122 5*, will be

$$S_{costs} = S_{gas} \quad 99 + S_{mazut} \quad 122\ 5 = 64 \quad 99 + 5\ 5 \quad 122\ 5 = \text{US \$}7{,}010$$

Commissioning costs

The cost of purchasing *ENERAC - 2000* combustion analyzer

$$C_1 = \text{US \$}5{,}000$$

Transportation and shipping costs C_2 = US $\$1,500$

Total $C_{TOTAL} = C_1 + C_2 = 5,000 + 1,500$ = US $\$6,500$

Estimation of simple payback period

Yearly saving of the fuel costs – S_{costs} = US $\$7,010$ per year

Commissioning costs – $Commis_{costs}$ = US $\$6,500$

Simple payback period is

$$SPP = Commis_{costs} / S_{costs} = 6,500 / 7,010 = 0\ 93 \text{ year}$$

ECO #3 INSTALLATION OF STEAM TRAPS IN THE STEAM UTILIZATION SYSTEMS

Description of the opportunity

At the plant steam with the pressure of *2 5* kg/cm^2 is used for the heating needs, hot water supply and processing purposes As it was mentioned in Section 5 3, the designed needs for the said purposes are correspondingly as follows ***13,040, 1,140*** and ***20,350*** Gcal However, for the incomplete loading of the production facilities of the plant, the factual heat consumption was in 1997 only ***2,802*** Gcal Besides, condensate is provided back only from Boiler Shop #22 Condensate in relation of the other systems is discharged into the canalization

As the audit results showed, the steam using equipment and the steam heating system are not equipped with steam traps, so the flash steam with the condensate with the temperature of ***105 - 110***°C are discharged into the canalization

To improve the efficiency of the steam utilization system the system for steam supply into the shops must be transferred from steam on water, all the steam using equipment must be provided with steam traps, condensate must be returned into the boiler-house Nowadays, the most loaded steam utilizing equipment is as follows the electric plating equipment in Workshop #21, the plant for drying stators (14 chambers) and *3* washing machines in Workshop #23, as well as the boilers in Workshops # 21, 22, 25, 27 and 31

It is proposed to install for the said equipment steam traps that will increase the efficiency of operation of the steam using equipment by ***10*** to ***15*** per cent and even more

Calculation of the yearly steam saving

We suppose that the efficiency of the steam using equipment will improve by *10*%

The results of the calculation are shown in Table A1

Table A1

Place of installation of the condensate assembles	Yearly steam consumption, Gcal	Saving of thermal energy, Gcal	Steam flow rate, kg/hour	Thermal power, Gcal/hour
1 Electroplating equipment in Workshop #21	254	25 4	950	0 61
1 Heat exchangers in the heat supply system and hot water supply system in Workshops # 21, 22, 25, 27 and 31	900	90	3,323	2 136
2 Plant for drying stators and washing machines in Workshop #23	150	15	560	0 36
Total	**1,304**	**130 4**		

The yearly saving of thermal energy will be ***130 4*** Gcal (***23,700*** m^3 of natural gas, ***2 05*** tonne of mazut) Saving of costs resulting from reduction of the steam consumption will be

$$S_{costs} = 23\ 7\ \ 99 + 2\ 05\ \ 122\ 5 = \text{US } \$2{,}598$$

Commissioning costs

It is proposed to install *8* steam trap assemblies equipped with the following products of ***Spirax Sarco***

Table A2

Place the steam trap assembly to be installed	Quantity, unit	Accessories to the steam trap assembly		
		Float Steam Trap	**Strainer**	**Check valve**
1 Electroplating equipment in Workshop #21	1	DN 20 FT 20-32 Cost US **$455**	DN 20 Fig 33 Cost US **$110**	–
2 Heat exchangers in the heat supply system and hot water supply system in Workshops #21, 22, 25, 27 and 31	5	DN 20 FT 20-32 Cost US **$455**	DN 25 Fig 33 Cost US **$110**	DN 20 DCV Cost US **$110**
3 Installation of a plant for drying stators and of washing machines in Workshop #23	2	DN 20 FT 20-32 Cost US **$455**	DN 20 Fig 33 Cost US **$110**	DN 20 DCV Cost US **$110**
Total cost	**8**	**US $3,640**	**US $880**	**US $770**

Total cost of the equipment with taking into account the transportation and other expenses

$$\text{US } \$5{,}920 \quad 1\ 3 = \text{US } \$6{,}870$$

Total commissioning costs

$$Commis_{costs} = \text{US } \$6{,}870$$

Estimation of the simple payback period

Saving of costs on thermal energy – S_{costs} =US $ *2,598* per year

Commissioning costs – $Commis_{costs}$ = US $*6,870*

Simple payback period is

$$SPP = Commis_{costs} / S_{costs} = 6{,}870 / 2{,}598 = 2\ 6 \text{ years}$$

Increasing the load at the plant will reduce the payback period up to *0 5* year

ECO #4 THERMAL INSULATION OF THE STEAM AND HOT WATER PIPES

Description of the opportunity

The carried our analysis of the steam distribution has shown that some steam pipelines and its branches, as well as the tube ducts of the hot water supply system had no insulation

The data concerning the broken insulation and the non-insulated pipeline system at the plant were received as the result of the measurements during the energy auditing, are given in Table A3

Table A3

Pipeline	Total length, m	Diameter, mm	Number of flanges	Number of valves	t^o, °C
1 Steam pipeline	200	89	4	2	120
2 Steam pipeline	320	50	4	2	120
3 Steam pipeline	110	40	-	-	120
4 Steam pipeline	80	25	-	-	120
5 Hot water supply	9	700	4	3	70
6 Hot water supply	20	50	4	3	70
7 Hot water supply	140	40	–	1	70

The boiler efficiency, according to the carried out measurements, is equal to ***85***%, while the efficiency of the steam distribution system is *78*% The steam boiler works currently all the year round, ***30*** hours per week, ***50*** weeks per year

It is proposed to insulate completely the steam pipe network and the network of the hot water supply system

The insulation thickness must be determined by the tube diameter and by the function of the pipeline (Table A4)

Table A4

Function	Diameter, mm	Insulation thickness, mm
1 Steam supply	40 to 89	80
2 Steam supply	25	20
3 Hot water supply	700	200
4 Hot water supply	40 to 50	42

Calculation of the yearly energy saving

We will determine the thermal losses for the insulated and for the non-insulated pipelines in accordance with the instructions [Methodical instructions concerning determination of losses of the fuel and energy resources *РД5 ЕДИВ 015 - 008 - 94*, Ministry for Machine Building Industry, Kyiv, 1994]

Losses of thermal energy (kcal/h) in the non-insulated pipelines can be determined by means of the formula

$$Q_{non-ins} = q_{non-ins} \; L_0 \; k \, ,$$

where $q_{non\ ins}$ – specific losses by the non-insulated pipelines, kcal/m h,

k – a correction coefficient the value of which depends on the temperature in the air and on the difference of the temperatures of the pipeline walls and of the air,

L_0 – a reduced length of the pipeline, m,

$$L_0 = L + (1\ \text{m}\ \ n) + (0{,}5\ \text{m}\ \ m),$$

n – the number of valves on the section, units,

m – the number of flanges on the section, units

For Pipeline #1 we will have

$$Q_{non\ ins} = 400\ \ (200 + 2 + 2)\ \ 0\ 96 = 78{,}336\ \text{kcal/h}$$

The further calculations were done in a similar way, the results are collected in Table A 3

Thermal losses from the non-insulated pipelines (kcal/h) can be determined by means of the formula

$$Q_{ins} = q_{ins}\ \ (t_1 - t_2)\ \ a\ \ b\ \ L_0,$$

where q_{ins} – specific losses by 1 m of a pipeline, if the temperature difference $(t_1 - t_2) = 1$°C depending on the insulation thickness, kcal/h,

t_1 – the temperature of the pipeline wall that is supposed to be equal to the ambient temperature, °C,

t_2 – the air temperature, °C,

a – a correction coefficient that depends on the insulation thickness, thermal conductivity of the insulating material and on the temperature difference between the heat agent and the air For the insulation thickness of up to *100* mm and the temperature difference of up to *300*°C we set $a = 1$,

b – a correction coefficient to take into account impact of the wind (if the wind speed is above *5* m/s)

Currently it is possible to speak about real decreasing the thermal losses in the thermal lines by using up-to-date efficient sorts of thermal insulating materials, such as cell plastic masses, for the steam pipelines and foam plastics for the condensate pipelines and others with the thermal conductivity of *0 03* to *0 05* kcal/(m h °C) We suppose that for the pipelines insulation the above said kinds of materials to be used

For Pipeline #1 from Table A4

$$Q_{ins\ 1} = 0\ 227\ \ (120 - 15)\ \ 1\ \ 1\ 03\ \ 204 = 5{,}008,\ \text{kcal/hour}$$

The similar calculations were done for all the pipelines, the results are given in Table A5

The net saving was received with taking into account the length of the pipeline, while the total saving - with taking into account the boiler efficiency and the efficiency of the steam distribution system

Table A5

Pipeline #	Reduced length	Thermal losses without insulation	Thermal losses with insulation	Net saving	Total saving
	L_0, m	$Q_{non\ ins.}$, kcal/h	$Q_{ins.}$, kcal/h	S, kcal/h	S_{total}, kcal/h
1	204	78,336	5,008	73,328	110,600
2	324	77,760	6,272	71,488	107,825
3	110	20,064	1,939	18,125	27,338
4	80	11,520	2,832	8,688	13,104
5	14	67,200	1,257	65,943	99,462
6	25	3,600	387	3,213	4,846
7	141	18,950	1,953	16,997	25,637
			Total	**257,782**	**388,812**

The yearly saving will be

$$S_{gas} = 388,812 \text{ kcal/h} \quad 30 \text{ h} \quad 50 \text{ weeks} \quad 10^{-6} = 583 \text{ Gcal/year},$$

which means *86,500* m³ of natural gas

Calculation of the yearly saving of costs

1,000 m³ of natural gas cost – C_{gas} = US $*99*

Yearly saving in terms of money is

$$S_{costs} = S_g \quad C_{gas} = 86\ 5 \quad 99 = \text{US } \$8,569$$

Commissioning costs

The total cost of the insulation required to be provided at the plant is

$$C_{ins} = L_{o_w} \quad C_{ins\ w} + L_{o_s} \quad C_{ins.\ s} = 180 \quad 8 + 718 \quad 10,5 = \text{US } \$8,979,$$

where L_{o_w} – the total reduced length of the pipelines for hot water supply # 5, 6, 7, 8 in Table A3, m,

L_{on} – the total reduced length of the pipelines # 1 to 4 in Table A5, m,

$C_{ins\ s}$, $C_{ins\ n}$ – the cost of *1* running metre of insulation respectively for the hot water supply system and for the steam supply system, US $/m

Installation works cost is

$$C_{inst.} = \text{US } \$3,000$$

So, in total the expected costs will be equal to

$$C_{expec.} = C_{ins} + C_{inst.} = 8,979 + 3,000 = \text{US } \$11,979$$

Estimation of the simple payback period

Yearly saving of costs – S_{costs} = US $*8,569* per year

Commissioning costs – $Commis_{costs}$ = US $*11,979*

Simple payback period is

$$SPP = Commis_{costs}/S_{costs} = 11,979 / 8\ 569 = 1\ 4 \text{ years}$$

ECO #5 PROVISION OF AN INFRA-RED HEATING SYSTEM

Description of the opportunity

They use air-and-register heating of Workshops # 22 (Machine Workshop), 23 (Mechanics and Assembling Workshop) and 31 (Tool Workshop) The maximum calculated consumption of heat in Workshop #22 is ***1,218*** Gcal per year, in Workshop #23 - ***1,407*** Gcal per year, in Workshop # 31 - ***789*** Gcal per year According to the data from the plant, the said purposes bring to consumption of ***1,500*** Gcal of heat In the conditions of an incomplete loading of the production facilities some of the heat is used non-reasonably, as heating of the whole building is provided, not only that of the working places

It is proposed to install in Workshops #22, 23 and 31, over the working places, infra-red heating systems instead of the currently existing heating systems

The proposed systems have several advantages as compared to the traditionally used systems

- saving of natural gas is ***30*** to ***50*** per cent,
- no need to move air streams, less "droughts" and creation of conformable conditions for working while the thermosetting temperature decreased by ***5*** to ***10***°C,
- quick attaining the required temperature in a room by heating first the floor, equipment, clothes and then the air using convection from them,
- opportunity to provide heating in separate zones where it is required by the processing schedule,
- availability of automatical controlling the temperature, and in particular provision of a stand-by heating in the non-working time and on week-days and days-off,
- simple and easy operation and maintenance

Calculation of the yearly energy saving

According to the data from the plant (see Appendix D) the heating needs in regard of Buildings # 22, 23 and 31, with taking into account the losses in the lines and excluding the air-and-thermal gate, there were used $Q_{heat./vent.}$ = ***1,1300*** Gcal of thermal energy or B_1 = ***260,000*** m^3 of natural gas (Table A6)

Table A6

Workshop	Total consumption, Gcal	Consumption with taking into account loading of the production facilities, Gcal
1 Machine Workshop #21	1,218	465
2 Machine Workshop #23	1,407	535
3 Tool Workshop #31	789	300
Total	**3,414**	**1,300**

It is proposed to install, taking into account the designed values of the thermal losses in the building, the following

- in the bay in Machine Workshop #22 – ***10*** highly-efficient heaters with the thermal production capacity of ***129*** Mcal/hour (***150*** kW),
- in the bay in Machine & Assembling Workshop #23 – ***10*** highly-efficient heaters with the thermal production capacity of ***129*** Mcal/hour (***150*** kW),

- in the bay of Tool Workshop #31 – *10* highly-efficient heaters with the thermal production capacity of *129* Mcal/hour (*150* kW)

The total installed capacity of the heaters is

$$N_h = 387 \text{ Mcal/h } (450 \text{ kW})$$

The maximum gas consumption pre hour will be

$$B_{g2} = l \quad b_e = 30 \quad 1\ 42 = 42\ 6 \text{ m}^3\text{/h},$$

where l – the number of the highly-efficient heaters, units,

b_e – the hourly consumption of natural gas by highly-efficient heaters, m³/h

With taking into account the stand-by mode that is *30%* of the consumption in the main operation mode, we receive for the full consumption of gas during a heating season as follows

$$B_g = B_{g2} \quad (t_1 \quad 114 + k_3 \quad t_2 \quad 114 + k_3 \quad 24 \quad 51) = 42\ 6 \quad (16 \quad 114 + 0\ 37 \quad 8 \quad 114 + 0\ 37 \quad 24 \quad 51) =$$
$$= 42\ 6 \cdot 3{,}052 = 130{,}000 \text{ m}^3,$$

where $t_1, t_2, 24$ – the time of operation of the heating system in the main, stand-by modes on the week days and on week-ends and days-off, respectively, hour,

114, 51 – the number of the working days and of the days-off during a heating season , days,

k_3 – the coefficient of the efficiency of utilization of the heaters' thermal energy in the stand-by mode

The gas saving will be

$$S_g = B_1 - B_g = 260 - 130 = 130{,}000 \text{ m}^3$$

Calculation of the energy cost saving

The cost of the natural gas used for heating the said workshops is

$$W_{Therm} = B_1 \quad C_G = 260 \quad 99 = \text{US } \$25{,}740,$$

where C_G– the cost of *1,000* m³ of gas, USD

The cos of the natural gas used for the infra-red heating is

$$W_G = B_G \quad C_G = 130 \quad 99 = \text{US } \$12{,}870$$

Yearly saving of the costs is $S_0 = W_G - W_G = 25{,}740 - 12{,}870 = \text{US } \$12{,}870$

Commissioning costs

There is proposed to install infra-red heaters of high- and low lighting intensity manufactured by the company "***Schwank***" operating on low-pressure natural gas

The cost of the equipment is

$$C_0 = l \quad P_{HI} = 30 \quad 516 = \text{US } \$15{,}480,$$

where P_{HI} – the price for the high-intensity heaters with taking into account VAT, USD

The commissioning costs (the project costs, gas supply system, installation works) will be set as $Commis_{costs} = \text{US } \$7{,}690$

Total costs

$$C_{total} = C_0 + Commis_{costs} = 15{,}480 + 7{,}690 = \text{US } \$23{,}170$$

Estimation of the simple payback period

Yearly energy costs saving – S_0 = US $*12,870*

Commissioning costs – $Commis_{costs}$ = US $*23,170*

Simple payback period is

$$SPP = Commis_{Costs} / S_0 = 23,170 / 12,870 = 1\ 8 \text{ years}$$

ECO #6 AUTOMATIC METERING OF ENERGY CONSUMPTION

Description of the opportunity

The enterprise consumes several sorts of energy resources electric power, gas, steam, compressed air, technical and drinking water

Electric power is supplied to the plant through three cable inputs of ***6***-kV each At the production area distribution of the electric power is done through transformer substations ***6/0 4*** kV with the total capacity of ***6,320*** kVA Commercial metering of electric power consumption is provided on the inputs The readings from the meters are made manually No technical metering is done at the plant

A detailed study of the plant showed that each subdivision of the plant calculates the amount of its independent consumption of steam, electric power, gas, compressed air, cold and hot water is done on the basis of the standard rates and actual volumes of the manufacture products No instrumental metering of energy resources consumption is available at the plant

It is proposed to automatized commercial and technical metering of energy consumption by means of the instruments for metering and checking the energy consumption produced by the Research Institute "***Enerhiya***", Kyiv City These metrological instruments are certified in Ukraine and they are designed for a continuous or periodical measuring/recording of physical parameters

Introduction into practice of **ITEK-x1x** allows its users to pay for the 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 the electric power consumption (that is different in time) and for making automatized 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 interfaces

ITEK-210 can be used together or instead of the installed ***OsT5000*** 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 R*75 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 incoming and outcoming pie lines (***ITEK-220***) and to Metering Group *1* and *2* (*1* objects) (***ITEK-320***)

For implementation of the measure there is planned to provide a commercial control of the electric power consumption in *6* check-points, a commercial metering of gas consumption in *1* check-point, that of drinking water - in *2* check-points, and that of steam consumption - in *2* check-points

Technical metering of electric power consumption will be provided in *20* points, technical metering of drinking water - in *10* points, that of technical water – in *16* points, that hot water – in *8* points, that of gas - in *3* points

Calculation of the yearly energy saving

Practice shows that after implementation at the plant of an independent automatical system for metering energy consumption and after introduction at the plant of a system for controlling and planning energy costs, one can expect to have energy saving not worse than *5* per cent

So, according to the data of energy consumption in 1997, saving of natural gas will be *25,500* m^3, that of electric power – *89,250* kW h, that of water - *1,300* m^3

Calculation of the yearly energy saving

Currently, the plant pays for the energy resources US $*565,000* Therefore, energy saving in the pecuniary form will be

$$S_{costs} = 656{,}000 \quad 0\ 05 = \text{US } \$28{,}250$$

Commissioning costs

The cost of the equipment and the costs of the works, USD

Commercial metering of consumption of electric power, gas, steam and drinking water USD*15,000*

Technical metering of consumption of electric power, hot water, drinking water, technical water, gas, steam US $*32,000*

Construction and commissioning works US $*8,000*

The total costs that can be expected C_{total} = US $*56,000*

Estimation of the simple payback period

Yearly saving of the costs - S_{costs} = US $*28,250* per year

Commissioning costs - $Commis_{costs}$ = US $*56,000*

Simple payback period is

$$SPP = Commis_{costs}/S_{costs} = 56{,}000/28{,}250 = 1\ 9 \text{ years}$$

ECO #7 AUTOMATIC CONTROL OF THE REACTIVE POWER COMPENSATION

Description of the opportunity

They use at the plant some devices for the reactive power compensation with the total capacity of *1,527* kVAr that are not equipped with systems for automatic controlling the connected power, which results in the average weighted power coefficient in the power supply system to the plant being significantly lower than the value set in the project (*cosφ = 0 975* on the *0 4*-kV side with taking into account the compensations), and it is equal, according to the data gained by the plant while making monthly loading plots for 1997, *cosφ = 0 652* The loading plot for the power supply line into Workshop #31 from ***RU-0 4*** kV in TP-302 for 24 hours on April 21, 1998 (appendix D) showed that At Production Ground #1 there is overcompensation, which results in varying of the power factor *cos φ = - 0 06 to 0 52* The low value for the power factor results in losses of electric power Besides, as it was shown by the results of measurements, the re-compensation brings rising of the voltage to *237 0 to 246.7* V, which leads to an abrupt reduction of the life time of the lighting devices

It is proposed to equip the devices for the reactive power compensation with an automatic control system

Calculation of the yearly energy saving

Reduction of electric power losses in the electric power supply lines by rising the power factor of the electric equipment devices will be

$$S = k \quad (W_{r1} - W_{r2}) = 0\ 08 \quad (1{,}368 - 412) = 77{,}500\ kW\ h,$$

where W_{r1}, kVAr x 10^3 – consumption of the reactive power before implementation of the proposal at the average weighted $tg\phi = 0\ 7666$,

W_{r2}, kVAr x 10^3 – consumption of the reactive power after implementation of the proposal at the average weighted $tg\phi = 0\ 23$,

k – the economic equivalent of the reactive power, $k = 0\ 08$ kW/kVAr

As it was notified in Item 5 2 in this Report, the enterprise has a set payment for the consumed reactive power– $q_{react.cons}$ = US $*0 72* per *1,000* kVAr h and for the declared reactive power – $q_{react.\ decl.}$ = US $*0 1334* per *1* kVAr that was set in 1997-1998 equal to *1,000* кkVAr

Introduction of the system of automatical controlling the plants for reactive power compensation will enable decreasing the payment rate for the reactive power by decreasing the declared power level and reduction of the total energy consumption

Table A7 shows the figures for electric power consumption by JSC MBPA *"Orion"* for 1997, the data were received from the plant

Table A7

Indicator	Unit	Value	
		factual ion 1997	after the implementation
1 Consumption of active power	kW h x 10^6	1 785	1 785
2 Consumption of reactive power	kW h x 10^6	1 368	0 412
3 Power factor, $tg\phi$	–	0 7666	0 2309
4 Declared value of the reactive power	KVAR	1,000	100
5 Payment for the declared reactive power	USD	1,678	167
6 The value of payment for the reactive power	USD	986	297
7 Decreasing the payment for the reactive power	USD		2,200

Implementation of this proposal will bring to decreasing of losses of electric energy in electric power supply lines by *77,500* kkW h, besides the payment for the reactive power will decrease too (see Table A7) by US $*2,200*

Commissioning costs

To provide compensation of the reactive power to the designed value of the power factor

$tg\phi = 0,23$, at the plant it is necessary to install, taking into consideration the real load, systems for controlling the cosine capacitors having the total capacity *1,527* kVAr The cost of the equipment and of the installation works will be US $*5,000*

Estimation of the simple payback period

Yearly saving of electric power – *77,500* kW h

Yearly saving of the costs – S_{costs} = US $*2,200* per year

Commissioning costs – $Commis_{costs}$ = US $*5,000*

Simple payback period is

$$SPP = Commis_{costs}/S_{costs} = 5,000 / 2\ 200 = 2\ 3 \text{ years}$$

With rising the loading at the plant the payback period will be shorter

ECO #8 UTILIZATION OF HIGHLY EFFICIENT LIGHT SOURCES

Description of the opportunity

The system for the external lighting of the territory of the plant includes *50* ***SPZR***-type illuminants with the mercury high-pressure lamps of ***DRL-400*** type (*16* units) and ***DRL-250***-type (*42* units) A part of the territory of the plant adjoining to the production buildings is lit with ordinary incandescent lamps with the capacity of *500* W The system of the internal lighting of Production Ground #1 of the plant includes ***1,463*** illuminants with lamps having the total capacity of *161* kW, Production Ground #2 - illuminants with lamps having the total capacity of *64 6* kW, Production Ground #3 - *780* illuminants with lamps with the total capacity of *73 2* kW, The total installed capacity of the lighting fixture for the internal lighting in the production rooms is *298 8* kW, including here *17* lamps of *DRL-400* type (**6 8** kW) and **123** lamps of *DRL-250* type (*30 75* kW)

It was found in the course of the energy audit that the average yearly capacity factor is *0 2* to *0 3* and the number of the illuminants switched at the same time is not higher than *30* per cent Therefore, when calculating the amount of the electric power consumed by the illuminants from the internal lighting system, providing a one-shift operation mode of the plant, it was set that in average ***a third*** of the lamps are switched *3* hours every day

The light flux of the ***DRL-400***-type lamp is ***23,000*** Lm, while its nominal life time is ***6,000*** hours, for the ***DRL-250*** type it is correspondingly ***10,000*** Lm and ***2,400*** hours

<u>It is proposed</u> a project of replacing the mercury lamps of *DRL-400* lamps used for the external lighting of the territory of the plant and for the internal lighting in the shops with the sodium high-pressure lamps of *DNaT-250-3* type, while the lamps of *DRL-250* type to be replaced with the lamps of *DNaT-100-3* types, and remain the current illuminants fixture but replacing the stating-up devices The sodium high-pressure lamps of *DNaT-250-3* type produced in the City of Poltava, Ukraine, have a longer life time – ***12,000*** hours at the illuminant flux of ***25,000*** Lm, while respectively for *DNaT-100-3* those are ***6,000*** hours and ***9,000*** Lm

Calculation of the yearly energy saving

"External lighting"

The electric power consumption by one ***SZPR*** illuminant equipped with ***DRL-400*** mercury lamp is

$$P_{ill.1} = (P_{L\,1} + P_{start\,1})\ \cos\varphi,$$

where $P_{ill.\,1}$ = 400 VA is the capacity of one ***DRL-400*** lamp,

P_{start1} = 85 VA is the capacity of the starting-up device,

$\cos\varphi = 0\ 98$

$$P_{ill.1} = (400 + 85)\ \ 0\ 98 = 475\,\text{W or } 0\ 475\,\text{kW}$$

The amount of the electric power that is consumed by *16* illuminants for a year, providing that they are switched in average *10* hours per day is

$P_1 = P_{ill.1}\ \ n_1\ \ F$,

where $n_1 = 16$ – it is the number of the illuminants,

$F = 10\ \ 365 = 3{,}650$ hours – the yearly fund of the operation time for an illuminant

$P_1 = 0\ 475\ \ 16\ \ 3{,}650 = 27{,}740$ kW h

The electric power of one ***SZPR*** illuminant with a sodium ***DNaT-250-3*** lamp is

$$P_{ill.2} = (P_{L\,2} + P_{start\,2})\ \ cos\varphi,$$

where $P_{L-2} = 250$ VA is the capacity of the ***DNaT-250-3*** lamp,

$P_{start2} = 34\ 7$ VA is the capacity of the starting-up device,

$cos\varphi = 0\ 98$

$P_{ill.2} = (250 + 34\ 7)\ \ 0\ 98 = 279$ W or $0\ 279$ kW

The amount of the electric power consumed by ***16*** illuminants for a year, if to switch them in average for ***10*** hours a day is

$P_2 = P_{ill\,2}\ \ n_1\ \ F = 0\ 279\ \ 16\ \ 3{,}650 = 16{,}294$ kW h

The yearly saving of electric power in the natural units, if to use *DNaT-250-3* lamps

$S_{el.pow\,1} = P_1 - P_2 = 27{,}740 - 16{,}294 = 11{,}446$ kW h

The electric power consumed by one ***SZPR*** illuminant with a mercury *DRL-250* lamp is

$$P_{ill.3} = (P_{L-3} + P_{start-3})\ \ cos\varphi\,,$$

where $P_{ill\,-3} = 250$ VA is the capacity of *DRL-250* lamp, W,

$P_{statr} = 54\ 1$ VA is the capacity of the starting-up device,

$cos\varphi = 0\ 98$

$P_{ill\,3} = (250 + 54\ 1)\ \ 0\ 98 = 298$ W or $0\ 298$ kW

The amount of the electric power consumed by ***42*** illuminants for a year, if in average each is switched for ***10*** hours, is

$P_3 = P_{ill.3}\ \ n_2\ \ F_1\,,$

where $n_2 = 42$ – the number of the illuminants,

$F_1 = 10\ \ 365 = 3{,}650$ hours – a yearly fund of the operation time of the illuminant

$P_3 = 0\ 298\ \ 42\ \ 3{,}650 = 45{,}683$ kW h

The electric power consumed by one ***SZPR*** illuminant with a sodium *DNaT-100-3* lamp is

$$P_{ill.4} = (P_{L-4} + P_{start-4})\ \ cos\ \varphi,$$

where $P_{L\,4} = 100$ W – the capacity of one *DNaT-100-3* lamp,

$P_{start-4} = 7$ W– the capacity of the starting device,

$cos\varphi = 0\ 98$

$P_{ill\,4} = (100 + 7)\ \ 0\ 98 = 105$ W or $0\ 105$ kW h

The amount of electric power consumed by ***42*** illuminants for a year, if in average each is switched for ***10*** hours per day is

$P_4 = P_{ill\,4}\ \ n_2\ \ F_1 = 0\ 105\ \ 42\ \ 3{,}650 = 16{,}097$ kW h

The yearly saving of electric power in the natural units, if to use *DNaT-100-3* lamps, is

$S_{el.power\text{-}2} = P_3 - P_4 = 45{,}683 - 16{,}097 = 29{,}586$ kW h

"Internal lighting"

The amount of the electric power consumed by ***6*** illuminants with *DRL-400* lamps for a year, if in average each is switched for ***3*** hours per day is

$P_5 = P_{ill\,1} \;\; n_3 \;\; F_2$,

where $n_3 = 6$ – the number of the illuminants,

$F_2 = 3 \;\; 365 = 1{,}095$ hours – a yearly fund of the operation time for the illuminant

$P_5 = 0\;475 \;\; 6 \;\; 1\;095 = 3{,}120$ kW h

The amount of the electric power consumed by ***6*** illuminants with *DNaT-250-3* lamps for a year, if in average each is switched for ***3*** hours per day, is

$P_6 = P_{ill\,2} \;\; n_3 \;\; F_2 = 0{,}279 \;\; 6 \;\; 1{,}095 = 1{,}833$ kW h

The yearly saving of electric power in the natural units, if to use *DNaT-250-3* lamps, is

$S_{el.power\text{-}3} = P_5 - P_6 = 3{,}120 - 1{,}833 = 1{,}287$ kW h

The amount of the electric power consumed by ***40*** illuminants with *DRL-250* lamps for a year, if each is switched for ***3*** hours per days, is

$P_7 = P_{ill.3} \;\; n_4 \;\; F_2$,

where $n = 80$ – the number of the illuminants,

$F_2 \;\; 3 \;\; 365 = 1{,}095$ hours – a yearly funs of the operation time for the illuminant

$P_7 = 0{,}298 \;\; 40 \;\; 1{,}095 = 13{,}052$ kW h

The amount of the electric power consumed by ***40*** illuminants with *DNaT-100-3* lamps for a year, if each is switched in average for ***3*** hours per day, is

$P_8 = P_{ill4} \;\; n_4 \;\; F_2 = 0\;105 \;\; 40 \;\; 1\;095 = 4{,}599$ kW h

The yearly saving of electric power in the natural units, if to use *DNaT-100-3* lamps, is

$S_{el.power4} = P_7 - P_8 = 13{,}052 - 4{,}599 = 8{,}453$ kW h

In the result, the yearly saving of electric power for the plan twill be

$11{,}446$ kW h + $29{,}586$ kW h + $1{,}287$ kW h + $8{,}453$ kW h = $50{,}772$ kW h

Calculation of the yearly saving of costs

Saving costs in the pecuniary units, if ***1*** kW h costs at the plant US $***0 0616,*** is

$S_{costs} = S_{TOTAL\,power} \;\; 0\;0616 = 50{,}772 \;\; 0\;0616 =$ US $3{,}128 per year

Commissioning costs

One *DNaT-250* lamp with the starting-up device costs - C_1 = US $35

One *DNaT-100* lamp with the starting-up device costs - C_2 = US $30

Commissioning costs $Commis_{costs}$ = US $35 22 + US $30 82 = US $3,230

The costs of the installation works is not included, as these works to be fulfilled by the plant itself

Estimation of the simple payback period

For the systems of providing the external and internal lighting the yearly saving of costs is

S_{costs} = US $\$3,128$ per year

Simple payback period

$SPP = Commis_{costs}/S_{costs} = 3,230 / 3,128 = 1\ 1$ years

As the life time of the chosen lamps is significantly longer than that for the currently used lamps, so the actual payback period may be shorter than one year

ECO #9 MONITORING OF THE OPERATION MODE OF THE BOILER EQUIPMENT AND OF THE TEMPERATURE OPERATION MODE OF THE HEAT UTILIZATION EQUIPMENT

Description of the opportunity

The plant has a branched steam-and-condensate system, hot water supply system as well as a heating system, but with that there are practically absent continuously working pressure gauges and thermometers monitoring the operation mode of the equipment It is impossible to carry out analysis of the efficiency of operation of the heat using plants, calculate the specific energy consumption, to identify in due time equipment faults

It is proposed to introduce at the plant a portable infra-red thermometer of ***"Reynger ST6"*** type, which will enable to carry out monitoring of the heat using equipment, to provide a regular control (*1 - 2* times a week) the efficiency of its operation and to undertake in due time measures aimed at decreasing losses of thermal energy Taking into account the state of the thermal using equipment and the level of its operation the expected improvement of the efficiency of heat utilization will be *2 0%*

Calculation of the yearly saving of heat

Yearly saving – *2 0%*

Yearly heat consumption – *2,802* Gcal

Expected heat saving

2,802 Gcal *0 02* = *56* Gcal,

which corresponds to *10,200* m^3 of natural gas and to *0 88* tonne of mazut

If *1,000* m^3 of natural gas cost US $*99*, and *1* tonne of mazut costs US $*122 5*, then decreasing of the energy resources costs will be

$$S_{costs} = 10{,}200 \text{ m}^3 \text{ US \$}99 + 0\ 88 \text{ tonne US \$}122\ 5 = \text{US \$}1{,}118$$

Proposed equipment and its cost

One infra-red thermometer of "***Reynger ST6***" type costs US $*1,000*

Estimation of the simple payback period

US $*1,000* / US $*1,118* = *0 89* year ≈ *11* months

ECO #10 MONITORING AND OPTIMIZATION OF THE POWER CAPACITY OF THE ELECTRIC EQUIPMENT

Description of the opportunity

According the data for 1997, the basic manufacture consume about ***66*** per cent of the total amount of the electric power consumed by the plant, which is ***1,183,000*** kW h per year that cost US $***730,000***

One of the basic consumers of electric power is electric drives for the processing, pumping and ventilation equipment

In the process of operation of the plant, if motors failed, they were replaced without taking into account the nominally required capacity As it was shown by the measurements of the power capacity of the electric equipment, providing the current loading of the production facilities, there is its underloading, and the potential of the electric motors is used only to ***30 - 40*** per cent Even if the equipment is of the same type, often there are used motors of different installed power capacity that is above the required value The total installed capacity of ***2,250*** motors used in the production processes is ***1,110*** kW The power capacity of the connected transformers is ***6,320*** kW Besides, there are other types of electric equipment with the total power capacity of ***2,885*** kW

To compensate the reactive power groups of capacitors with the total added power capacity of ***1,527*** kVAr All said equipment requires monitoring and controlling of the loading modes

It is proposed to introduce at the plant operational control of the power that is actually consumed by the electric equipment (and primarily by the electric drives) using for that a set of portable instruments and by measuring the power factor Implementation of the proposed measure will allow to carry out monitoring of the actual loading of the electric equipment, analyze its efficiency and organize its planned replacement with more efficient one Implementation of this proposal will permit to save mot less than ***1 5*** per cent of electric power that is used for the processing needs during a year

Calculation of a yearly saving

1 Yearly electric power consumption – ***1,183,000*** kW h

2 ***1,000*** kW h cost – US $***61 6***

3 Expected electric power consumption – ***1 5***%

4 Expected saving

1,183,000 kW h ***0 015 = 17,700*** kkW h

5 Decreasing the costs

17,700 kW h US $***61 6*** = US $***1,093***

Proposed equipment and its cost

The cost of one set of portable instruments such as "***2000 A Wattprobe***" and "***Power Factor Meter, TIF 2300***", with taking into account the overhead and transportation costs, is US $***1,000***

Simple payback period is

US $***1,000 /*** US $***1,093 = 0 91*** year ≈ ***11*** months

APPENDIX B PRELIMINARY SPECIFICATIONS

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Table B 1

Specifications for the equipment to be delivered to JSC MBPA "Orion"

Designation in Section 7	Equipment	Type, model	Manufacturer country	Basic parameters	Needs		Price		Delivery cost		Примечания
					Unit	Quant	UAH	USD	UAH	USD	
1	2	3	4	5	6	7	8	9	10	11	12
ECO #1	Non-contact infra-red pyrometer	Model ***ST6***	"***Raynger***", США	***t = -20 + + 1000***°C $L_{MESUR} = 10$ m	unit	1	–	1,000	–	1,000	
	Analyzer of electric loading	Model ***DRANETZ***	"***Dranetz Technologies, Inc*** США		unit	1	–	5,000		5,000	
	Portable anemometer	Model ***444HT***	"***Kurz Instruments, Inc***, США		unit	1	–	1,300	–	1,300	
	Tester	Model ***87***	"***Fluke Mig Co, Inc***, США		unit	1	–	500	–	500	
	Power factor meter	Model TIF 2300	"***TIF Instruments, Inc***", 9101 N W 7th Avenue Post Office Box 1338 Miami, Florida 33238-9990,		unit	1		600		600	
	Watt-meter	Model ***TIF 2000 A***	"***TIF Instruments, Inc***", 9101 N W 7th Avenue Post Office Box 1338 Miami, Florida 33238-9990,		unit	1	–	600	–	600	
ECO #2	Gas analyzer	***ENERAC - 2000***	***Energy Efficiency Systems, Inc***, 1300 Shames Drive, Westbury, NX 11590 США	ANALYZED GASES O_2, CO_2, SO_2, NO_x	unit	1	–	5,000	–	5,000	
ECO #3	Float steam mm traps	***FT 20-32***	"***Spirax Sarco Inc*** Company P O BOX 119 ALLENTOWN, PA	***DN = 20*** ***Py = 16*** kg/cm²	unit	8	-	445	-	3,640	
	Condensate filter	***FIG33***	"***Spirax Sarco Inc*** Company P O BOX 119 ALLENTOWN PA	***DN = 20*** ***Py = 16*** kg/cm²	unit	8	-	110	-	880	

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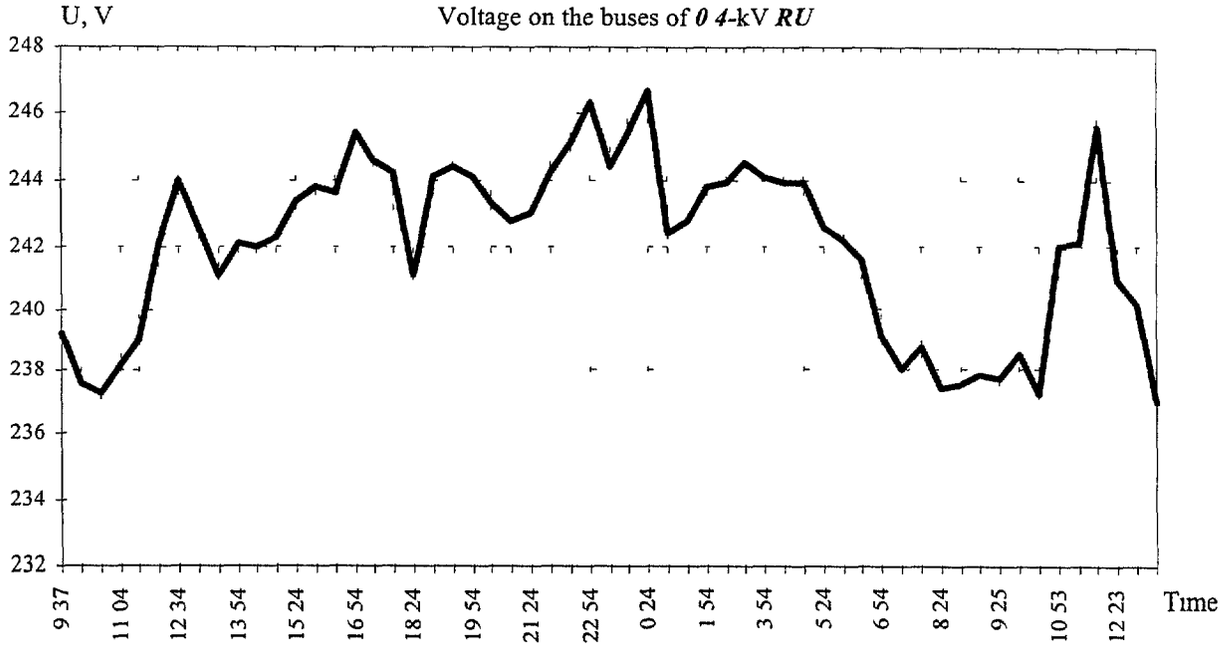
1	2	3	4	5	6	7	8	9	10	11	12
	Check valve	*DCV*	*'Spirax Sarco Inc "* Company P O BOX 119 ALLENTOWN, PA	*DN = 20* *Py = 16* kg/cm²	unit	7	-	90	-	770	
ECO #4	Thermal insulating materials for steam supply pipelines	Glass fiber with a cover of aluminum	USA	*t = 150*°C	m	718	19 5	10 5	1,400	7,540	
	Thermal insulating materials for hot water supply pipelines	Foampolyuretan	JSC Vasylkiv Refrigerator Plant 72, Soborna Str , Vasylkiv, Kyiv Region, Ukraine	*t = 100*°C	m	180	15 9	8	2,860	1,440	
ECO #5	Highly efficient infra-red gas-fire heaters	*JR - 50*		*P = 15* kW	unit	30		516		15,480	
ECO #6	A set of instruments for energy metering and controlling	*ITEK* (component base of the USA)	R&PA "Enerhiya" , 37, Peremoha Prospekt, Building 22, 252056, Ukraine	Commercial metering Technical metering	unit unit	1 1		15,000 32,000		15,000 32,000	
ECO #7	Systems for automatic controlling the condensate plants	*UKM 62-0,4*		*U = 0 4 kV*						5,000	
ECO #8	High-pressure sodium lamp with a starting-up fixture)	DNaT-250-3 DNaT-100-3	OJSC "Poltava Gas-Discharging Lamps Plant , 3, Zavodska Str , Poltava, Ukraine	*U = 220* V *P = 250 W* *P = 100 W*	unit unit	22 82	– –	35 0 30 0	– –	770 2 460	

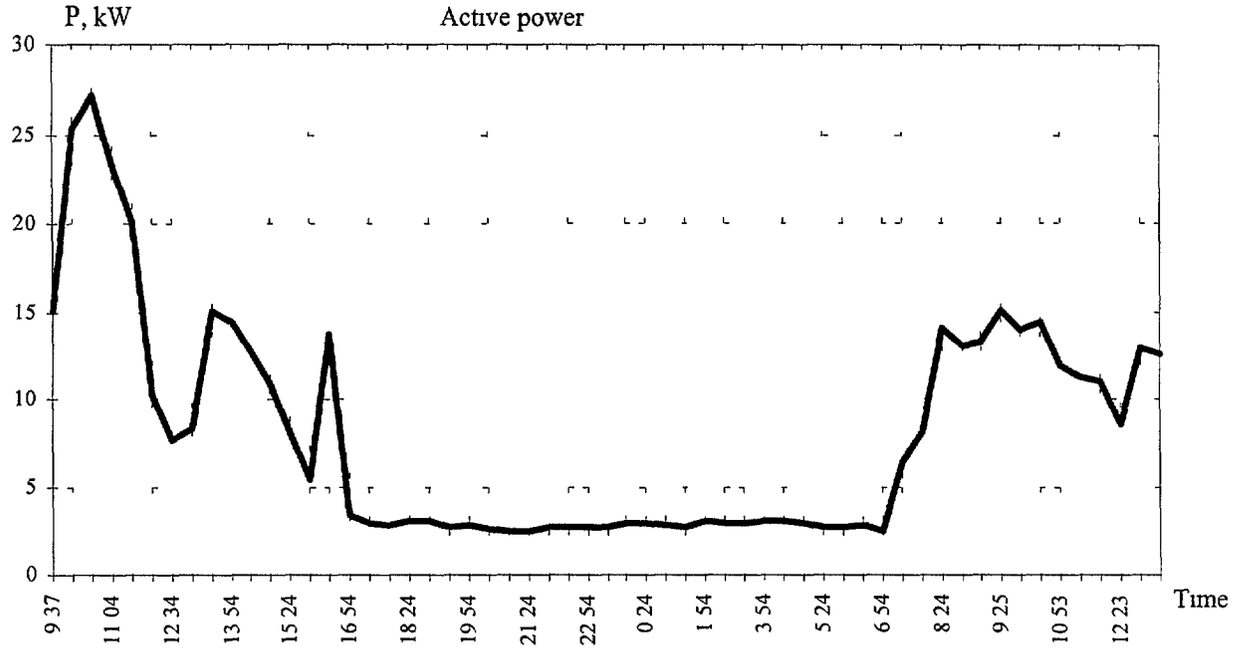
APPENDIX C AUDIT RECORDS AND PLANT DATA

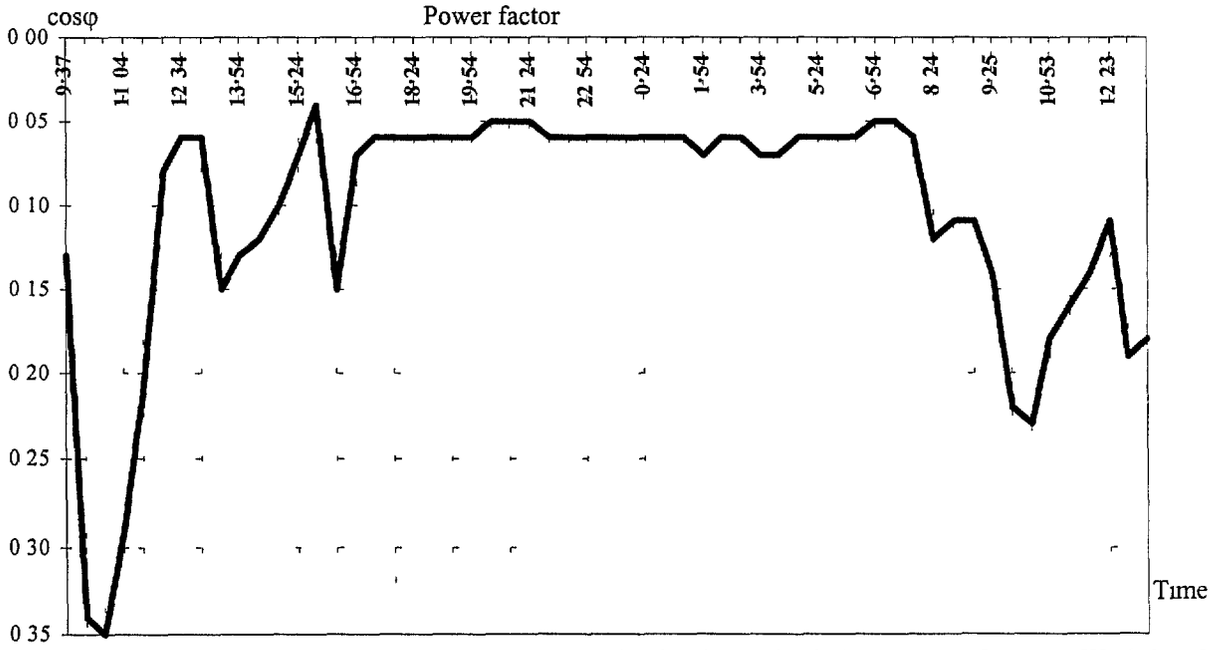
The results of the measurements of the natural gas combustion efficiency in Boiler #1 of DKVR-6,5-13 type at OJSC MBPA "Orion" on April 24, 1998 (the steam pressure was ***2 0*** kg/cm^2)

Measurement #1 (behind the boiler)	Measurement #2 (behind the boiler)	Measurement #3 (before the exhaust fan)
BACHARACH MODEL CA300NSX ********** ** COMBUSTION ANALYZER	BACHARACH MODEL CA300NSX ********** ** COMBUSTION ANALYZER	BACHARACH MODEL CA300NSX ********** ** COMBUSTION ANALYZER
ID	ID	ID
SER NO VCO 512	SER NO VCO 512	SER NO VCO 512
TIME 10 18	TIME 10 22	TIME 10 07
DATE 21, 04, 98	DATE 21, 04, 98	DATE 21, 04, 98
FUEL NATURAL GAS	FUEL NATURAL GAS	FUEL NATURAL GAS
PRIMRY TEMP <C> 25	PRIMRY TEMP <C> 25	PRIMRY TEMP <C> 24
STACK TEMP <C> 119	STACK TEMP <C> 124	STACK TEMP <C> 30
% OXYGEN 16,6	% OXYGEN 16,6	% OXYGEN 20,8
% EXCESS AIR 352	% EXCESS AIR 352	% EXCESS AIR 276
% CARBON - DIOXIDE 2,4	% CARBON - DIOXIDE 2,4	% CARBON - DIOXIDE 0,1
PPM CARBON - MONOXIDE 20	PPM CARBON - MONOXIDE 21	PPM CARBON - MONOXIDE 42
PPM MOX 7	PPM MOX 7	PPM MOX 6
PPM SULFUR - DIOXIDE 0	PPM SULFUR - DIOXIDE 0	PPM SULFUR - DIOXIDE 13
% EFFICIENCY 85,3	% EFFICIENCY 84,3*	% EFFICIENCY 83,5*
% STACK LOSS 14,7*	% STACK LOSS 15,7*	% STACK LOSS 16,5*
TEST PERFORMED BY	TEST PERFORMED BY	TEST PERFORMED BY

* – without taking into account the temperature of the blown air







Results of measurements at *TP302* of parameters for the electric loads for a group of users in Workshop 31, April 21 - 22, 1998

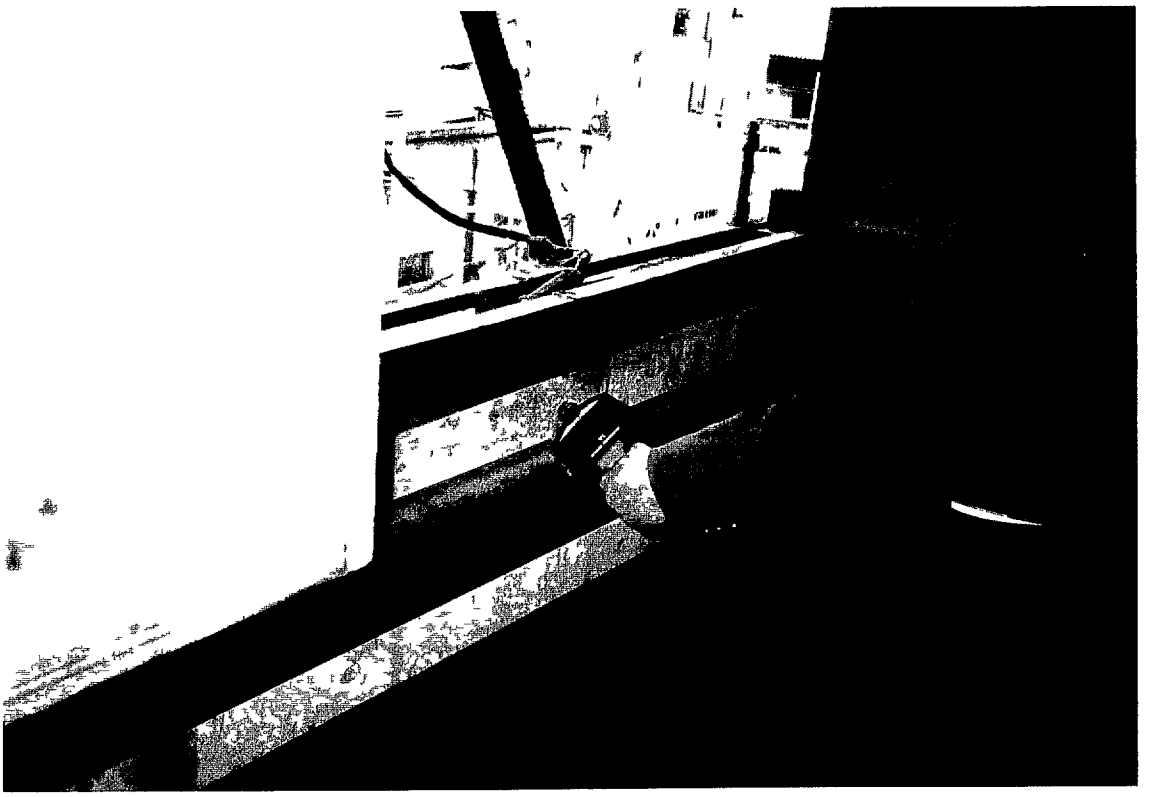
APPENDIX D PHOTOGRAPHS OF THE PLANT

Проходная производственной площадки №1
State of the boiler and condensate trapping assembles in the boiler-house

Административный корпус производства №3
Administration Building for Production Ground #3

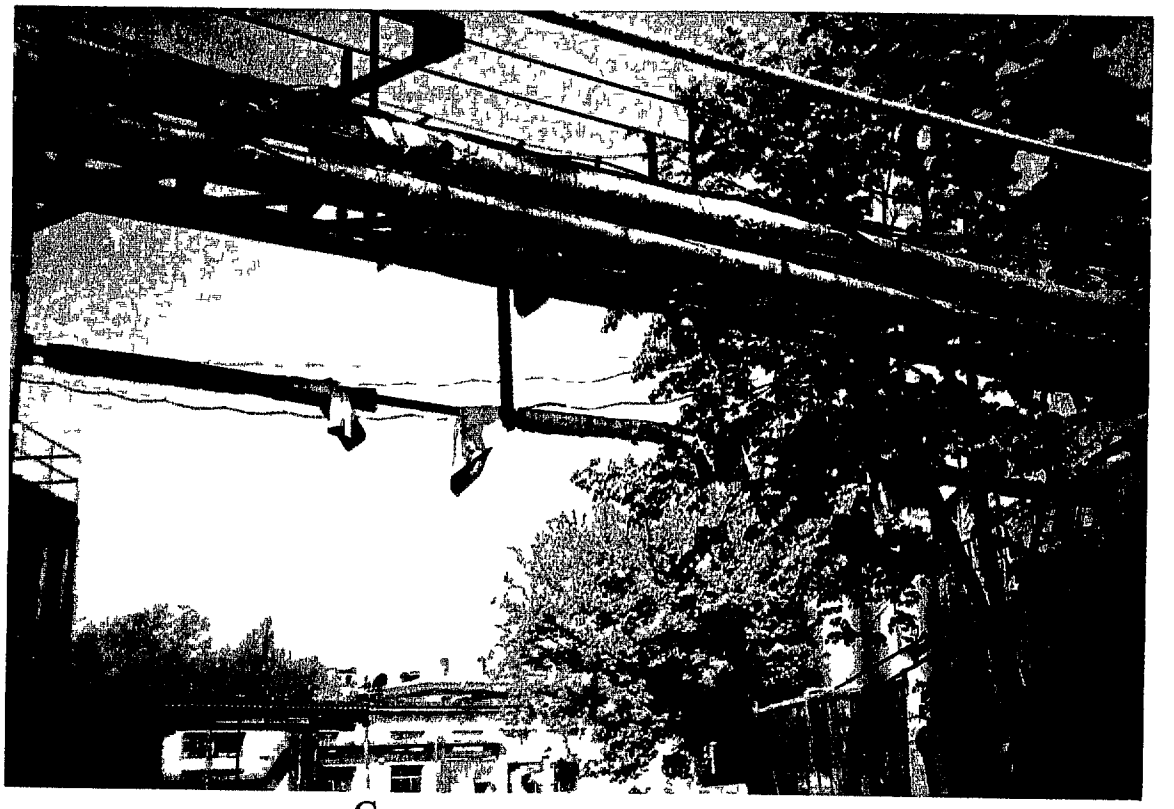
Строительство нового корпуса ОАО МПО “Орион”
Construction of a new building at OJSC MBPA “Orion”

Измерение содержания уходящих газов на котельной
Measurement of the exhaust gases content in the boiler-house

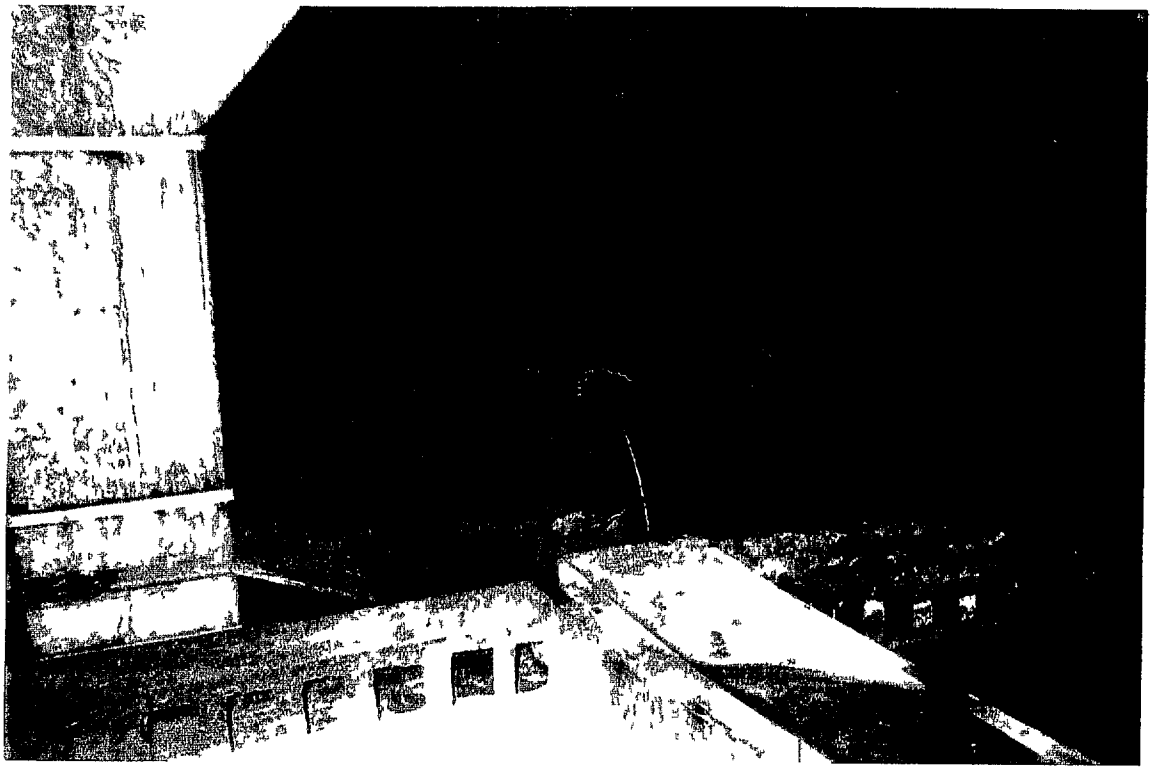


+112 ^{0}C на поверхности регистра парового отопления при открытом окне
+112^{0}C on the surface of the steam heating register if the window is open

Прямые потери пара
Direct losses of steam

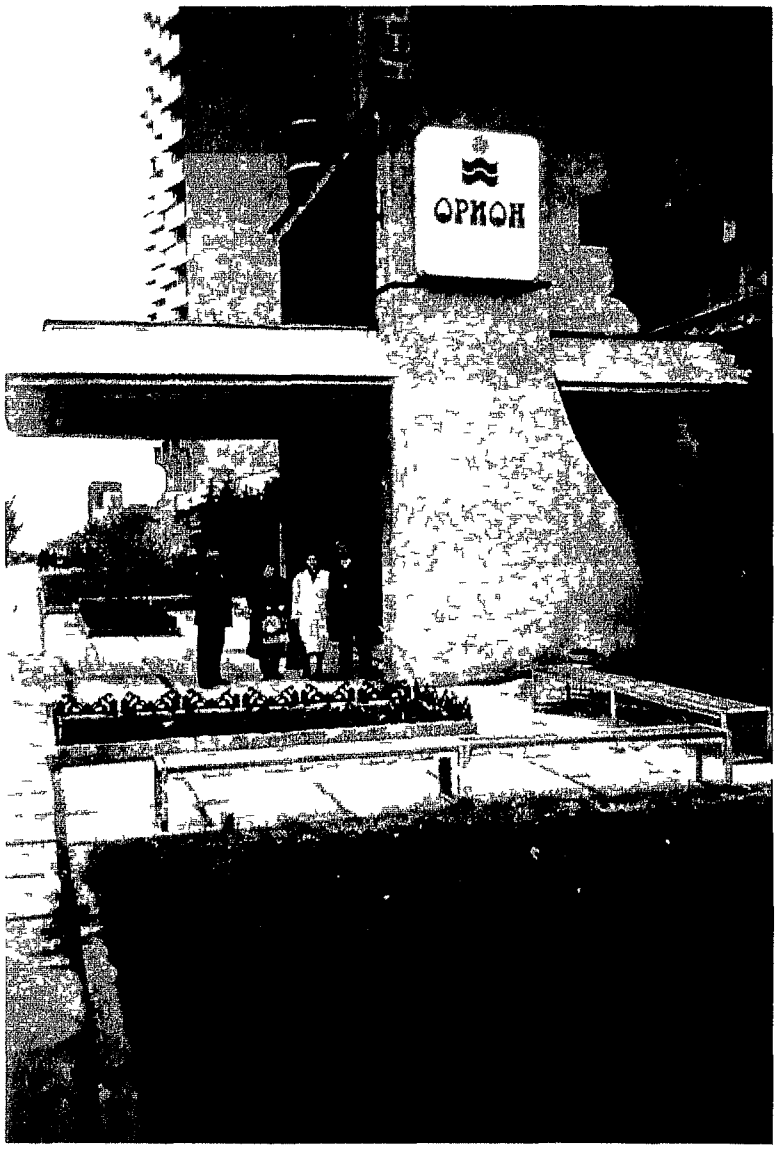


Состояние термоизоляции
State of the thermal insulation



Потери тепла в гальваническом участке
Heat losses in the electroplating workshop

Сброс конденсата в канализацию
Discharging condensate into the canalization system



Лечебно-оздоровительный комплекс ОАО МПО "Орион"
Health Care and Protection Combined Facilities at OJSC MBPA "Orion"

APPENDIX E CONVERSION FACTORS

CURRENCY EQUIVALENTS

1 hrn - a Ukrainian money unit
1 hrn = 0,5 x US $1 (the state on April 1998)

CONVERSION FACTORS

HEAT

1 cal = 4 187 J
1 kcal = 4 187 kJ = 3 968 Btu
1 Gcal = 4 187 10^3 MJ = 4 187 GCal
1 Btu = 1,055 J = 1 055 kJ = 1 055 10^{-3} MJ

POWER

1 W = 3 6 10^3 J = 3 6 kJ
1 kW = 3 6 10^3 kJ = 3 6 MJ = 860 kCal
1 MW = 3 6 10^3 MJ = 0 86 GCal
1 kcal = 1 163 10^{-3} kW
1 Gcal = 1163 kW = 1 163 MW
1 kW = 1 36 HP
1 kW = 1 34 hp

PRESSURE

1 kgf/cm^2 = 1 barg
1 barg = 101 325 kPa = 0 1 MPa
1 bar = 10^5 Pa = 100 kPa = 0 1 MPa

LENGTH UNITS

1 mm = 0 0394 in = 0 00328 ft
1 cm = 0 3937 in = 0 0328 ft
1 m = 39 37 in = 3 281 ft

WEIGHT UNITS

1 g = 2 2046 10^{-3} lb
1 kg = 2 2046 lb
1 t = 1000 kg = 2 2046 10^3 lb

AREA UNITS

1 cm^2 = 0 155 in^2 = 1 076 10^{-3} ft^2
1 m^2 = 1 55 10^3 in^2 = 10 76 ft^2

VOLUME UNITS

1 m^3 = 35 31 ft^3 = 1000 l
1 l = 35 31 10^{-3} ft^3
1 l = 0 264 gal (US)

HEAT CONTENT

1 kJ/kg = 0 43 Btu/lb
1 kJ/m^3 = 26 84 10^{-3} Btu/ft^3
1 MJ/m^3 = 26 84 Btu/ft^3
1 kcal/m^3 = 4 187 kJ/m^3 = 0 112 Btu/ft^3

TEMPERATURE

°C = 0 56 (°F – 32)

APPENDIX F ABBREVIATIONS

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ABBREVIATIONS

ESCO	- energy servicing company
ECO	- energy conservation opportunity,
Fig	- figure,
hrn	- hryvnia,
tel	- telephone,
USAID	- United States Agency for International Development,
VAT	- value-added tax,

barg - atmosphere gauge
^{0}C - degrees Celcius
cm^2 - centimeter squares
^{0}F - degrees Fahrenheit
g gram
Gcal - gigacalorie
h - hour
kCal - kilocalorie
kg - kilogram
kV - kilovolt
kW - kilowatt
kW h - kilowatt hour
m - meter
m^2 - meter squared
m^3 - meter cubed
min - minute
t - tonne
t/h - tonnes per hour
W - watt