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Industrial Energy Efficiency - Ukraine
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REPORT
ON ENERGY AUDIT
AT Open Joint-Stock Company "PRESMASH", 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, it s financial conditions, its generation and 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

The given report includes the findings of the energy audit performed by ***Burns & Roe Enterprise, Inc*** at the Open Joint-Stock Company "PRESMASH" in April 13 to 17, 1998

1 EXECUTIVE SUMMARY

1 1 Introduction

The Open Joint-Stock Company "Presmash" (JSC "Presmash") is an up-to-date enterprise that is one of the largest in Ukraine in the field

Aiming at a continuous renewing of the production, searching new technologies allow the plant to manufacture products with guaranteed quality

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

A team consisting of two representatives of the company **Burns and Roe Enterprise, Inc** - energy management experts Mr Viktor Lvovich Svistunov and Mr Vladimir Vasilyevich Prokopenko performed an energy audit at OJSC "Presmash" in April from 13 to 17, 1998 according to the objects of the project and prepared this report

There were certain reasons to restrict the audit to one week However, the engineering personnel was prepared for development of measures that could be implemented for the whole plant In many cases there occurred a necessity to focus the energy audit works on one processing line or on one plant department Hence, the given audit is based on what we really managed to do for a week Though the audit already includes a whole set of recommendations for the plant management, it is expedient to make a complete integral energy audit of the plant It is desirable that the plant management should invite specialists prepared within the framework of this project to continue the work, which must bring to improvement of the whole situation with energy consumption at the plant and to making the full list of the measures to be used to improve the energy consumption at the plant

1 2 Principal findings

- OJSC "Presmash", against the Ukrainian standards, is considered to be quite a reliable enterprise
- *63*% of the total energy consumption at the plant is electric power consumption As natural gas consumption is concerned, about *60*% is used in the boiler-house, and *35*% – by the thermal equipment in the casting and smith-and-pressing workshops These uses are the basic ones that determine the main opportunities for energy conservation In the net cost of the products *20*% are the energy costs
- As expected, the audit group found a lot of attractive opportunities for improvement of energy efficiency on the current energy 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
- Absence of a system for technical metering the energy consumption by separate workshops prevents from setting-up a basis for energy conservation and to introduce into practice an energy management system
- A significant energy saving reserve is improvement the efficiency of natural gas utilization by improving the combustion modes in the thermal plants in the casting workshop and in the

boiler-house, as well as by using steam traps, improving the thermoinsulation of the steam- and condensate ducts, hot water supply pipelines

- Reduction in energy consumption can be received by improving the efficiency of using the ventilation system, heat supply system, system for production and utilization of compressed air, by using highly efficient light sources

1 3 Recommendations

The below table 1 1 shows a list of energy conservation opportunities (ECOs) identified for the facility, as well as estimated energy savings and cost savings and the simple payback period for each of the opportunity, the majority of them have the simple payback period up to one year So, ECO #1- "Organization of an energy management system" will enable to set a regular work aimed at energy saving at the plant, for what a division for energy management shall be set-up The latter shall be responsible for controlling and analyzing the energy consumption at the plant, as well as for development of recommendations and a reconstruction plan or for improvement of any systems that can lead to energy saving

To encourage the facility to implement energy efficiency and energy conservation, USAID is contributing energy auditing equipment to the plant This equipment consists of standard energy auditing instrumentation and meters that will enable them to implement an energy management system

ECO #2 "Adjustment of boiler-aggregates operation modes", by optimization of the natural gas combustion processes in the boiler, with the help of using a portable combustion analyzer, will enable to improve the combustion efficiency and, as the result, to reduce gas consumption потребление

ECO #3 by redesigning the system for hot water preparation form the needs of the hot water supply system which consists in replacement of the *DE-6,5-13*-type boiler with a **100**-kW capacity water-heating boiler, there shall be reduced consumption of natural gas for the above needs,, the latter are accounted for by frequent starts of the power boiler, low load and low efficiency

ECO #4 "Thermal insulation of steam pipelines, pipelines in the hot water supply system" will enable to reduce thermal energy losses on the sections with the total length of ***252*** m

ECO #5 "Improvement of the level of the reactive power compensation in the electric power supply system" from $tg\phi_1 = 0\ 7666$ to $tg\phi_2 = 0\ 23$ will enable to receive saving of ***228,000*** kW h per year

ECO #6 by introduction of ***150*** efficient light sources instead of the *DRL-250*-type lamps and the incandescent lamps in the external lighting system at the plant, its reliability should be improved and the total electric power consumption should be decreased

ECO #7 "Improvement of the efficiency of operation of drying furnaces in the casting workshop" by insulating the gates of the glass furnaces, doing adjustment of the operation modes and introducing urgent control of the natural gas combustion process with using combustion analyzers, all that will enable to decrease consumption of natural gas

ECO #8 "Automation of metering the consumption of energy resources" will enable to provide without manual work a real situation in regard of the energy consumption at the plant, support the reasons for conducting energy saving works, prove the true figures for the energy consumption by the plant units providing the self-supporting basis of fulfilling the activities

ECO #9 suggests to use instead of the air heating system for the whole space in a partially idling workshop only heating the working places by means of highly-efficient infra-red gas-fire heaters , which will enable to decrease the consumption of natural gas by ***50%***

ECO #10 to provide reduction in electric power consumption by replacing the water pump with excessive capacity and head pressure that is used in the compressor station cooling system with a pump of lower capacity

ECO #$11 introduction of instrumental control, use of the installed capacities of the electric equipment will enable to eliminate the non-reasonable operation modes and provide decreasing the non-reasonable utilization of electric power

ECO #12 "Thermal insulation of the hot water accumulating tank" will provide saving of natural gas by eliminating direct losses of thermal energy and decreasing the time for warming-up the boiler after its having been shut down

The capital investments of **USD *66,107*** aimed at improvement of the energy efficiency with the short-term payback periods (ECO # 2, 4, 9, 10, 11 and 12) will lead to the yearly saving of **USD *237,400***, as well as to decreasing the electric power consumption by **USD *151,800*** kW h and that of natural gas by ***1,345,000*** m^3 The investments of **USD *131,275*** aimed at improvement of the energy efficiency with the simple payback periods of more than one year (ECO #1, 3, 5, 6, 7, 8) will bring to the yearly saving of **USD *80,505***, as well as to decreasing in consumption of electric power by ***1,106,700*** kW h and in that of natural gas by ***223,600*** m^3

The total decrease in the electric power consumption will be ***1,258,500*** kW h (***16 3***% of the consumption for 1997), and that in the consumption of natural gas will be ***501,600*** m^3 (***35 8***% of the consumption for 1997) If to take into account use of the infra-red heaters, the saving of natural gas will be ***1,568,600*** m^3

The total decrease in the amount of emissions into the atmosphere of harmful substances resulting from implementation of the proposed measures will be 22 tonnes, including there in particular 5 54 tonnes of solid particles, 0 82 tonne of carbon oxides, 3 14 tonnes of nitrogen oxides and 12 46 tonnes of sulfur oxides

Table 1 1

List of energy conservation opportunities

# ECO	Description	Saving of electric power, kW h x 10 ³	Saving of natural gas, m³ x 10³	Saving of water, m³ x 10³	Yearly saving, USD (in prices for 1997)	Costs of the measures, USD (in process for 1997)	Simple payback, yr
1	Organization of an energy management system	386	70 1	8	27,200	33,500	1 2
2	Adjustment of the boiler aggregates operation modes		140		13 860	6 500	0 47
3	Redesigning the hot water preparation system	28 2	28		4 020	9 000	2 2
4	Thermal insulation of the steam pipelines and the hot water supply pipelines		118 7		15 021	4 677	0 3
5	Automation of the plants for controlling the devices for compensating the reactive power	228			6,860	8 000	1 17
6	Introduction of energy efficient light sources	78 3			3 443	8,275	1 9
7	Improvement of the efficiency of operation of the drying furnaces in the casting workshop		55 4		5 482	7 520	1 37
8	Automation of metering the consumption of energy resources	386 2	70 1	8	33 500	65,000	1 9
9	Introduction of infra red gas fire heating systems in the plant production buildings		1,067 0		200,534	48,800	0 24
10	Optimization of the compressor plants cooling system	35 8			1 575	270	0 17
11	Monitoring and optimization of the power consumption by the electric equipment	116			4,500	5 104	0 9
12	Thermal insulation of the hot water accumulating tank		19 3		1 910	756	0 4
	Total	**1,258 5**	**1,568 6**	**16**	**317,905**	**197,382**	

The above energy conservation measures can be implemented at other industries, that is in other words they can be considered like standard settlements of solving 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 OJSC "Presmash", 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 PRESMASH *Plant* are about **20** per cent of the total cost of the products produced

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

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

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

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

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

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

1 5 Implementation

Implementation of the measures given in Table 1 1 is planned after completion of the following project phases and after agreement of the equipment to be introduced

2 GENERAL BACKGROUND

Name of the enterprise – Open Joint-Stock Company "Presmash"

Director – Mr Leonid Fedorovych Vykhvoten'

Chief Engineer – Mr Valentin Anatoliyovych Kacherovskyi

Tel (0482) 22 - 38 - 23

Fax (0482) 33 - 93 - 12

Address Presmash Plant, 28, Stolbovaya Str , Odesa City, Ukraine, 270098

2 1 Plant History

The plant was founded in 1952 It is located in the western industrial area in Odesa City between the stations Zastava *I* Zastava *II* at Odesa Railway Section

The territory of the plant is made up by two production grounds the main ground is *13 5* ha, the warehouse ground is *6 7* ha

The profile of the plant is manufacture of different sorts of smith-and-pressing machines

The presses manufactured by the plant were used first for mastering of production of the synthetical fiber

Annually the plant manufacture about *50* sorts of smith-and-pressing machines, the total list of the plant assortment includes about *130* kinds of the smith-and-pressing machines that provide *40* technologies of processing materials by pressing

On the territory of the industrial area of the plant the following buildings and structures are located

- Building #1
  - mechanical workshop for processing components for cases and bodies,
  - machine (mechanical) workshop for middle-size parts,
  - mechanical workshop for hydraulic equipment,
  - assembling workshop,
  - painting section,
  - conservation and packaging section,
  - ancillary services,
  - utility rooms
- Building #2
  - electroplating-and-thermal processing workshop,
  - mechanical workshop for heavy presses,
  - heavy presses assembling workshop,
  - basic components area (Scoda),
  - painting section,
  - conservation and packaging section, washing machines area,
  - ancillary services,
  - utility rooms
- Building #3
  - tool workshop,

- repair and maintenance workshop,
- workshop for consumers goods,
- utility rooms,

- Building #4
  - foundry,
  - ancillary rooms,
  - utility rooms,
- Building #5
  - pattern workshop,
  - stock-house of the operation and dispatching department,
  - utility annex,
- Building #6
  - cutting area within the ГТЦ workshop,
  - workshop for welded structures,
  - mechanical workshop for the parts for thermoplastic automatical machines,
  - ancillary services,
  - utility rooms,
- boiler-house,
- compressor station,
- administration building

In 1995 Odesa Plant for Presses and Automatical Machines was reorganized into the Open Joint-Stock Company "Presmash" The shares were distributed in the following way *26*% – to the state, *74*% – to the personnel of the enterprise and to individuals

Historically "Presmash" is the largest manufacturer and supplier of thermaplastical automates for processing of plastical presses, presses and special presses of different sorts, remaining the only in the CIS-countries manufacturer of thermoplastautomates with the injection volume of above ***2000*** cm^3, presses for in-pressing and dispressing the pairs of wheels and some other equipment

2 2 Types of products

At the present time "Presmash" Plant manufactures various kinds of machines among which first of all there should be mentioned the following ones

- casting machines for processing thermal flexible and thermal reactive plastic masses with the force of ***250*** to ***5,000*** tonnes,
- presses for briquetting metal chips with the force of ***400*** to ***630*** tonnes,
- tube-bending machines,
- presses for packaging sheet metal wastes,
- presses for isothermal pressing,
- presses for deep drawing and special presses,
- hot-pressing multi-positional, hydroelectric pulse machines for machine-building, aviation, civil engineering, metal processing and other branches of industry

The current number of the personnel is *1,122* persons

2 3 Significance of the sector for the state economy

There are in Ukraine plants of the similar profile However, concerning some sorts of the products this plan remains to be the monopolist not only in Ukraine, but in the CIS-countries

Shipment of the equipment versus the shipment places is as follows

10% – the far abroad area,
60 - 65% – the CIS-countries,
25 - 30% – Ukraine

3 CURRENT STATUS OF PRODUCTION

3 1 Maximum estimated productivity

The designed production capacity of the enterprise provides manufacturing of products on UAH ***40,217,000***

3 2 Actual production capacity 1997 against 1995 and 1996

Between 1995 and 1997 plant operated not being loaded completely, the load was not higher than *12 5%*, which was accounted for by re-orientation of the suppliers of components for the equipment, reduction of the paying capabilities of the customers The production volumes are shown in Table 3 1

Table 3 1

Production volumes

Name	Measure unit	Production level			% in 1997 against 1996
		1995	1996	1997	
1 Volume of the goods for sale - in total, and including	hrn x 10^3	3,355	4,442	5,006	**113**
2 Manufacture of thermoplastmachines	hrn x 10^3	860	1,184	679	57
3 Manufacture of special presses	hrn x 10^3	967	2,320	3,145	136
4 Precise-bending machines	hrn x 10^3	570	141	36	26
5 Co-operated shipping	hrn x 10^3	219	227	336	148

Analysis of the data in Table 3 1 shows that the absolute volumes of production in 1996 as comparing them with those in1995 were as follows for thermoplastmaschines – *137 7%*, for the special presses – *240%*, for the precise bending machines – *25%*, the co-operated shippings were *103 7%*, the total amount of the goods for sale was *132%*

The similar absolute production volumes in 1997 as comparing them with those in 1996 were as follows *57%*, *136%*, *26%*, *148%* and the total amount of those for sale was *113%* There is evident a trend to increasing the production rates

3 3 Development of prospects

The marketing, processing and technical services of the plant are engaged in works aimed at prospective development of the facility In particular, the association is actively engaged in enlarging the assortment of the products for sale

3 4 Export vs Domestic Consumption

The Association exports its products The total amount of such sale is up to *75%*, including also that to the CIS-countries that is up to *65%*

These data show that the plant has reliable position on the external market

4 FINANCIAL STATUS OF THE PLANT

4 1 Currency vs Barter

In its economic activities of the OJSC "Presmash" the barter operations are a significant part "

So, in 1995 the barter operations were *38 5*%, in 1996 – *21 5*%, in 1997 – *56 9*%, which can be explained by the payment crisis in Ukraine

4 2 Viability of the plant

The main financial results of the operation of the plant are shown in Table 4 1 Their analysis suggests the idea that the balance profit of the plant in 1997 was *1 46* times higher than that in 1996, while the gross income was higher by *1 39* times

Table 4 1

Main financial results

Indicator	**Values vs the years, hrn x 10^3**		
	1995	**1996**	**1997**
1 Gross income	2,703	3,521	4,902
2 VAT	337	215	605
3 Costs of manufacturing of the products	1,657	2,663	3,655
4 Balance profit	883	787	1,145
5 Net profit	500	389	495

The data in Table 4 1 show that in 1997, as compared with 1996, the gross income increased by *39*%, the production costs by *37*%, which together with the data from Table 3 1 allow to make the conclusion about improvement of the financial status of the plant during the recent two years

The data of the viability of the plant shown in Table 4 2 have satisfactory values, they show a stable financial status

Table 4 2

Indicators of the financial stability

Indicator	1995	1996	1997
1 Profitability, %	22 6	5 8	11 5
2 Liquidity factor	5 18	20 8	19 22

The plant has no delays in payments for the energy resources

The expense bills and the income bills are kept for each year in form of special books

5 YEARLY ENERGY CONSUMPTION AND PRICES

5 1 Consumption in 1997 against that in 1995 and 1996

At the OJSC "Presmash" 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 *4* kg/cm^2 is generated by the boiler-house of the plant that is equipped with boilers of DKVR-10/13 and DKVR-6,5/13 (water heating) and with one DKVR-6,6/13 boiler (a steam boiler) The yearly consumption and the energy costs are shown in Table 5 1 The electric power and natural gas consumptions are correspondingly ***33 75***% and ***66 25***% of the total energy consumption at the plant However, if the cost is considered, the figures are somewhat different electric power - ***55 9***%, natural gas - ***20 5***%, drinking water - ***23 6***%

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	7,723,000 kW h	6,642	33 75	334,730	55 9
Natural gas	1,402,000 m^3	13,039	66 25	122,398	20 5
Drinking water	160,000 m^3	–	–	141,267	23 6
Total	–	**19,681**	**100 0**	**598,395**	**100 0**

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

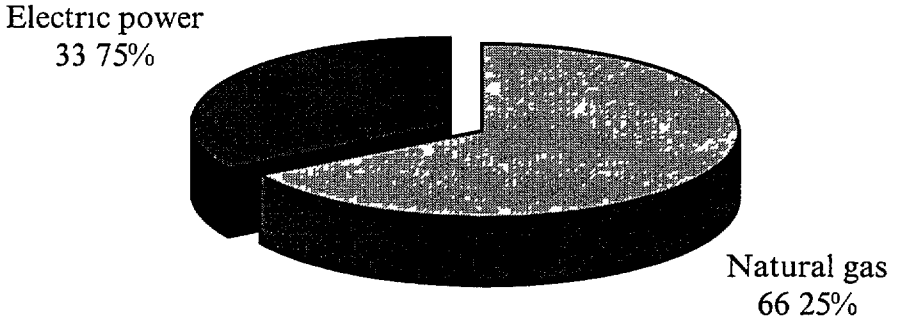


Fig 5 1 Distribution of energy resourses for 1997

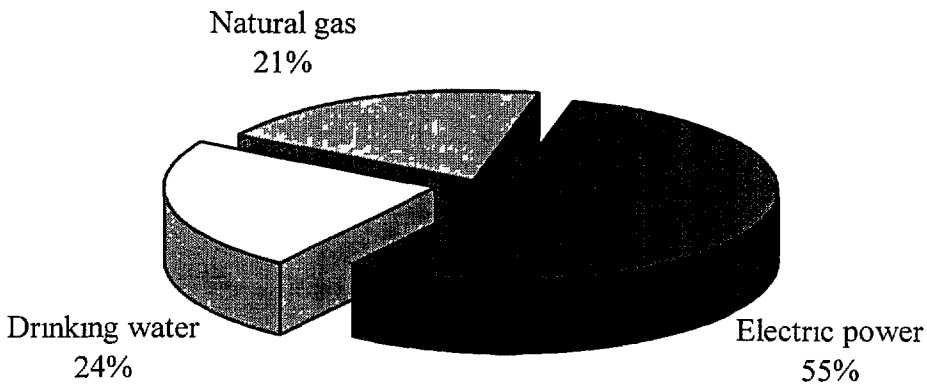


Fig 5 2 Energy costs distribution for 1997

Table 5 2

Energy consumption at OJSC "Presmash" for 1997

Month in 1997	Electric power consumption, kW h x 10^3	Gas consumption, 1,000 m^3
January	1,114	453
February	849	350
March	904	103
April	723	56
May	494	33
June	497	8
July	370	0
August	207	0
September	365	22
October	548	41
November	711	114
December	943	222
Total	**7,725**	**1,402**

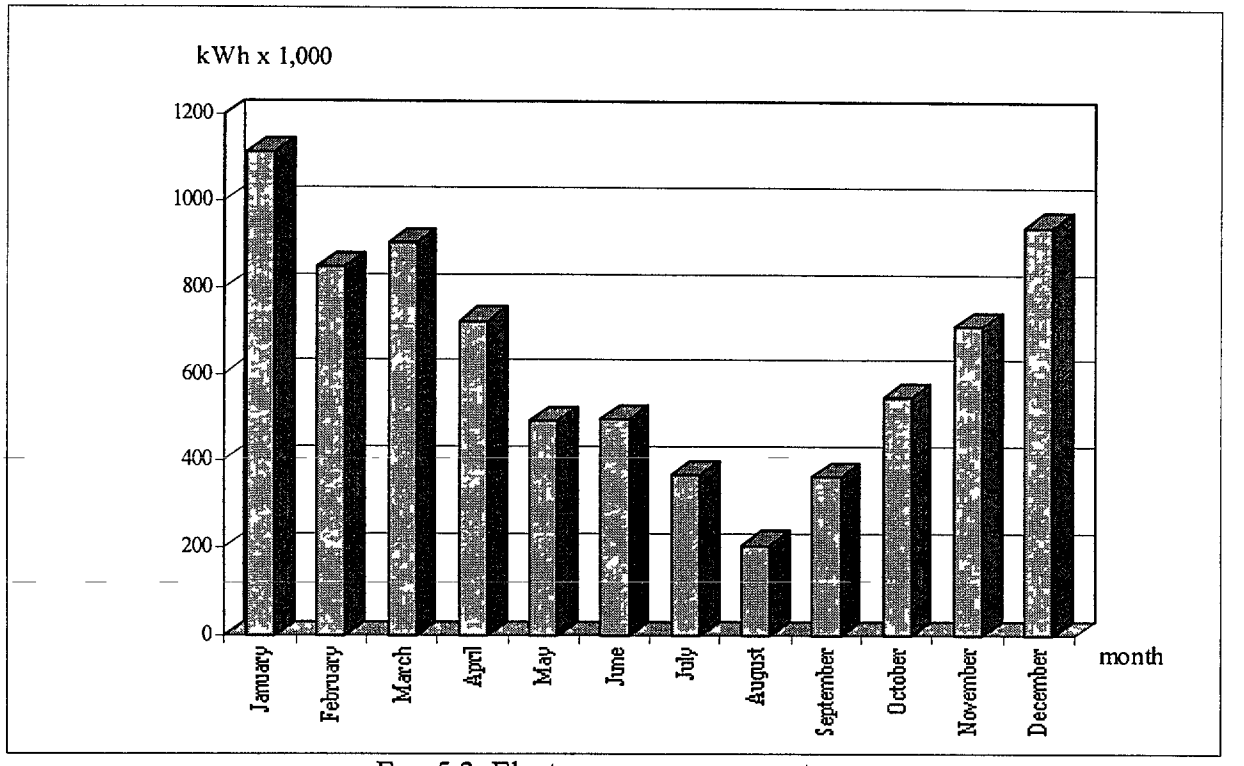


Fig 5 3 Electric power consumption

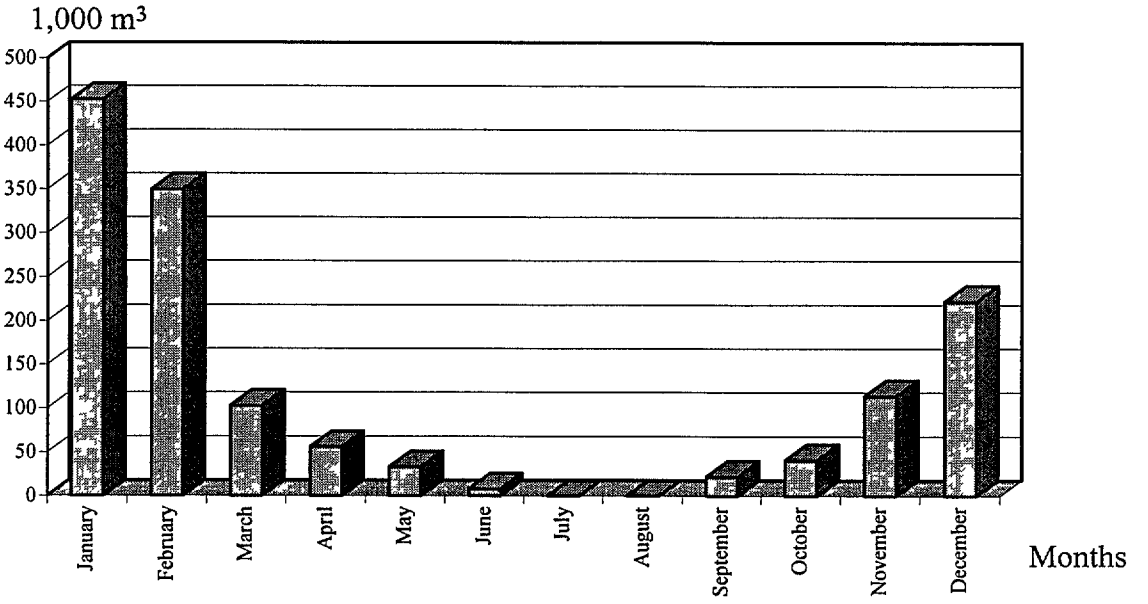


Fig 5 4 Gas consumption

The total consumption of electric power in 1997 was ***7,723,000*** kW h, that of natural gas – ***1,402,000*** m^3, of water – ***160,000*** m^3 The period of the largest production load is in Quarters ***I*** and ***IV*** The maximum consumption of natural gas in 1996, 1997 was in winter period, and for 1997 it was ***453,000*** m^3 The yearly plots for consumption of electric power and natural gas show evidently a decrease in energy consumption in summer time which is accounted for by the impact of the load for providing heating

5 2 Current tariffs on energy and fuel

OJSC "Presmash" in 1997 paid for the energy resources USD ***670,000*** The energy costs are about ***20***% of all production costs That is why the measures aimed at energy saving can noticeably improve the financial indicators for the plant

The system of payment for electric power is a two-rate based tariff with paying for the used reactive power Once a year the plant makes a contract with an electric power supplying organization concerning the payment for electric power consumption According to this contract, there must be provided a preliminary payment of a set amount of the consumed electric power The utilization of the set amount of electric power is checked every months by the readings of the meters of the active power that are provided on the input feeders

Currently the agreed price on electric power is USD ***3 8*** per ***1*** kW of the officially ordered amount of power, USD ***0 035*** per ***1*** kW h of the used amount of power, USD ***0 0028*** per ***1*** kVAr of the used reactive power The averaged tariff is USD ***0 044*** 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 in the boiler-house There are gas meters at the gas distribution station Gas consumption is paid for monthly on the basis of USD ***83*** per ***1,000*** m^3 Since November 1, 1997 the price of gas has been USD ***99*** for ***1,000*** m^3

Drinking water is provided to the plant through two flow-rate meters from the city water supply system The price on water is USD ***0 075*** per ***1*** m^3

5 3 Profile of energy utilization

Production areas and shops consume the following sorts of energy resources

- electric power is supplied to the plant from an intermediate distribution station "Zahrava" within the State Joint-Stock Energy Company "ODESAOBLENERGO"
  - * the production ground is provided with electric power from three distribution ***3*** stations of ***6*** kV each and, further, from ***16*** voltage converting-down substations for ***6/0 4*** kV with the installation capacity of ***15,360*** kVA The power voltage for the electric power consuming devices is ***380*** V, ***50*** Hz, that for the lighting fixture is ***220*** V, the frequency in the main power supply line is ***50*** Hz The installed capacity of the electric power consuming devices is ***73,300*** kW

The electric power supply system includes ***39*** compensators with the total capacity of ***7,690*** kVA in the ***0 4***-kV circuit, with the total capacity of ***690*** kVA in the–***6***-kV circuit

The following equipment consumes electric power electric furnaces, high-frequency current plants with electric machines, electric welding plants, electroplating tanks, rectifiers, electric calorifers, heating devices, electric drives differing in their capacities and types, electric lighting fixture

- natural gas is provided to the plant from the city gas supply line, that is a pipe of ***279*** mm, and through one flow-rate meter The operation input pressure varies from ***0 5*** kg/cm^2 (in winter) to ***3*** kg/cm^2 (in summer)

  The basic gas consumers are
  - the boiler-house with three boilers ***DE-6,5-13*** (a steam boiler), ***DKVR-6,5-13*** (a water heating boiler), ***DKVR-10-13*** (it is under repair currently),
  - a foundry shop with a two-chamber furnace, a furnace for drying bars, five posts for drying moulds,
  - electroplating and thermal processing workshop with plasmic furnaces,

- a workshop for welded structures with the gas-dismantling posts for metal cutting,
- the utility and everyday loads

- drinking water is provided from the city water supply system through two inlets and two water consumption meter The maximum water consumption is ***324,000*** m^3/yr The ,plant has ***25*** functioning water circulation supply systems with the maximum water circulation amount of ***2,500,000*** m^3/yr
- thermal energy - it is generated in the central boiler-house

  The basic plants consuming thermal energy are as follows
  - heating and ventilation systems in the production workshops, hot water supply systems in the plant workshops,
  - the electroplating workshop, wood drying, emulsion preparation
  - heating of the building for the Main Design Bureau, combined facility, etc
- the compressed air with the pressure of ***8*** kg/cm^2 is generated by the central compressor station equipped with compressors of *VP-50/8* and *2M-10-50/8* types that have the drive capacity ***300*** kW Compressed air is used in all production workshops

The figures for the production output between 1995 and 1997 are shown in Table 3 1, the figures concerning the energy consumption for all sorts of products and works are given in Tables 5 3, 5 4 and 5 6

There is no instrumentally-based metering of the used amount of natural gas, thermal energy versus the production areas, workshops, sorts of products, so there are absent objective estimations of the electric energy consumption concerning the said aspects Currently these estimations are done by the department for economics of the plant by calculation on the basis of designed specific consumptions and volumes of the manufactured production The data concerning the consumption of fuel and energy resources are reported in the state documentation Form #11 *мтп* "Report on fuel, thermal energy and electric power consumption"

Consumption of natural gas by the plant depends on the needs of the productions subdivisions in steam and hot water The yearly consumption of thermal energy in 1996 was ***10,412*** Gcal, and that for 1997 was ***9,618*** Gcal

Table 5 3

Year	Production of thermal energy, tonnes of conventional fuel (tcf)	Casting of pig iron, tcf	Forging, tcf	Thermal processing, tcf	Drying of moulds, tcf
1995	935	110	35	32	255
1996	723	81	38	40	150
1997	579	60	66	61	274

Fig 5 5 Consumption of natural gas versus sorts of products or works

Table 5 4

Years	Total consumption , Gcal	Products for machine building industry, Gcal	Domestic purposes, Gcal
1995	9,843	5,667	4,176
1996	10,412	4,382	6,030
1997	9,618	3,509	6,109

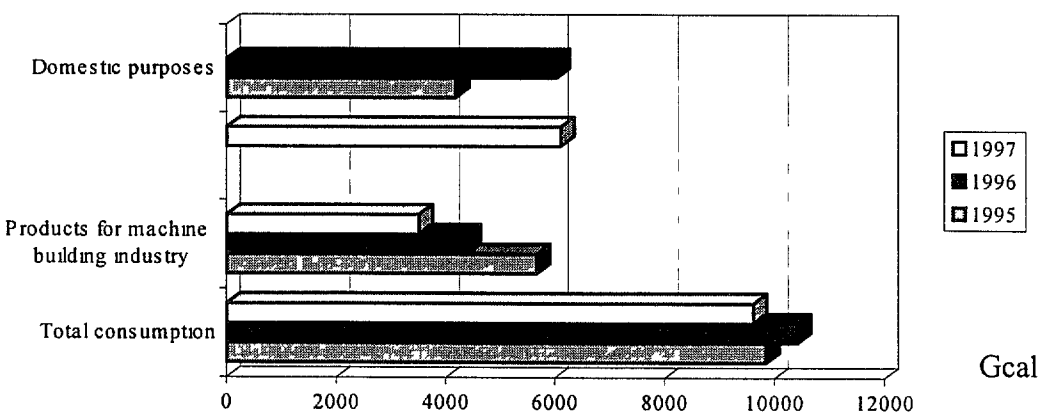


Fig 5 6 Consumption of thermal energy versus the sorts of products or works

Table 5 5

Years	Total consumption, kW h x 10^3	Products for machine-building industry, kW h x 10^3	Domestic purposes, kW h x 10^3
1995	6,274	5,837	437
1996	7,678	5,489	2,189
1997	7,723	5,309	2,414

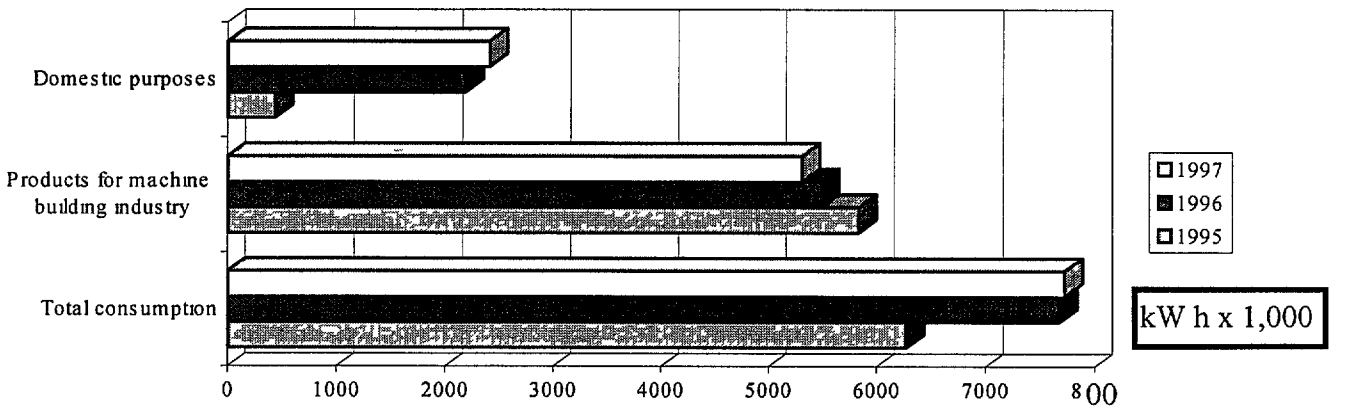


Fig 5 7 Consumption of electric power versus the sorts of products or works

Energy consumption balances for the production subdivisions are shown in Fig 5 8 - 5 10

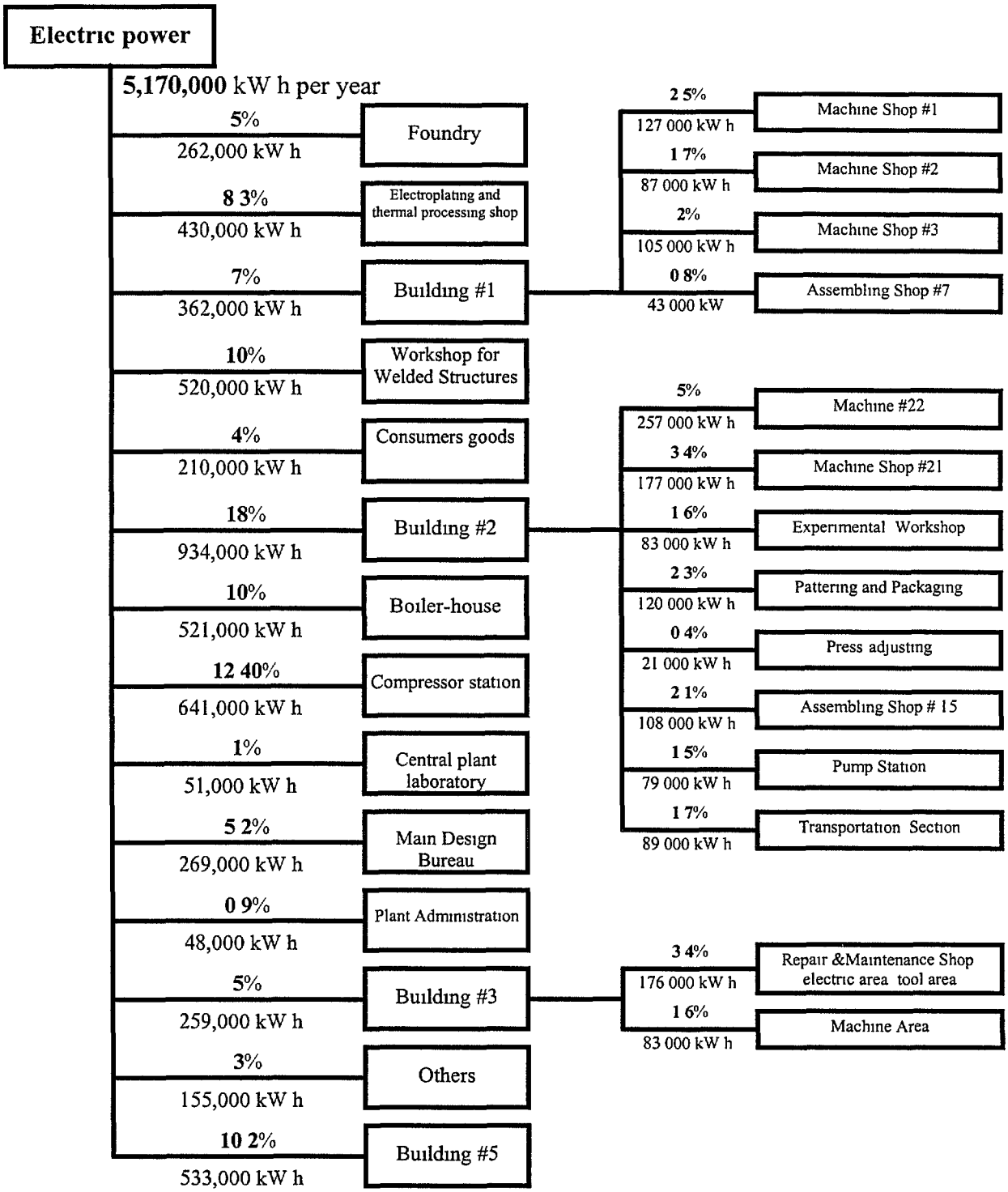


Fig 5 8 Balance of electric power consumption at OJSC "Presmash" for 1997

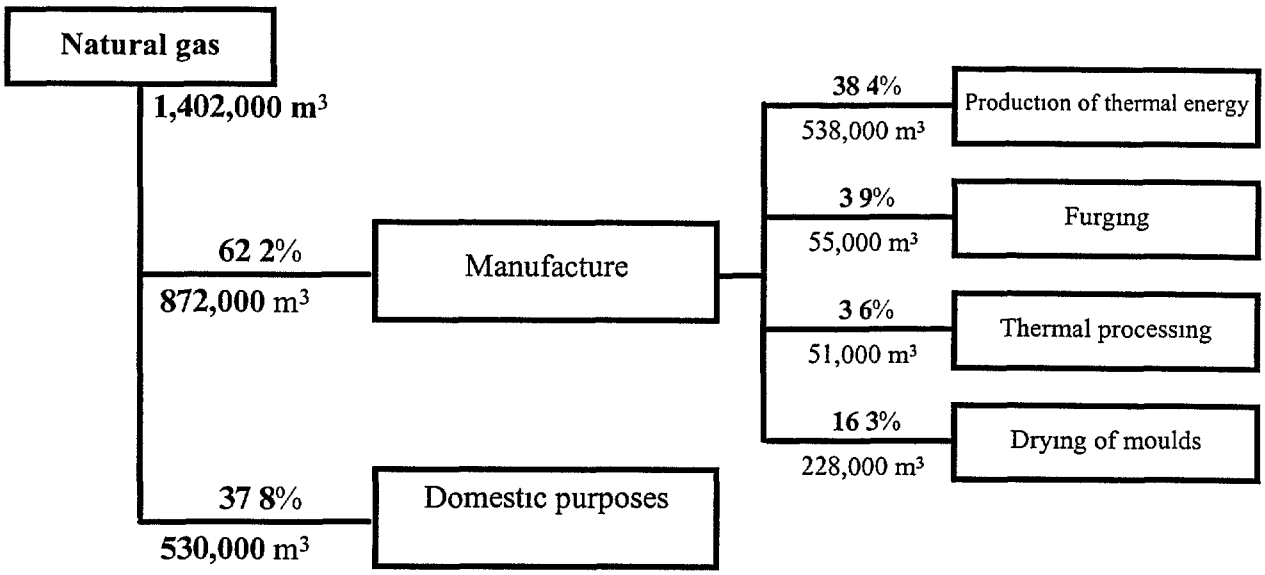


Fig 5 9 Balance of natural gas consumption at OJSC "Presmash"

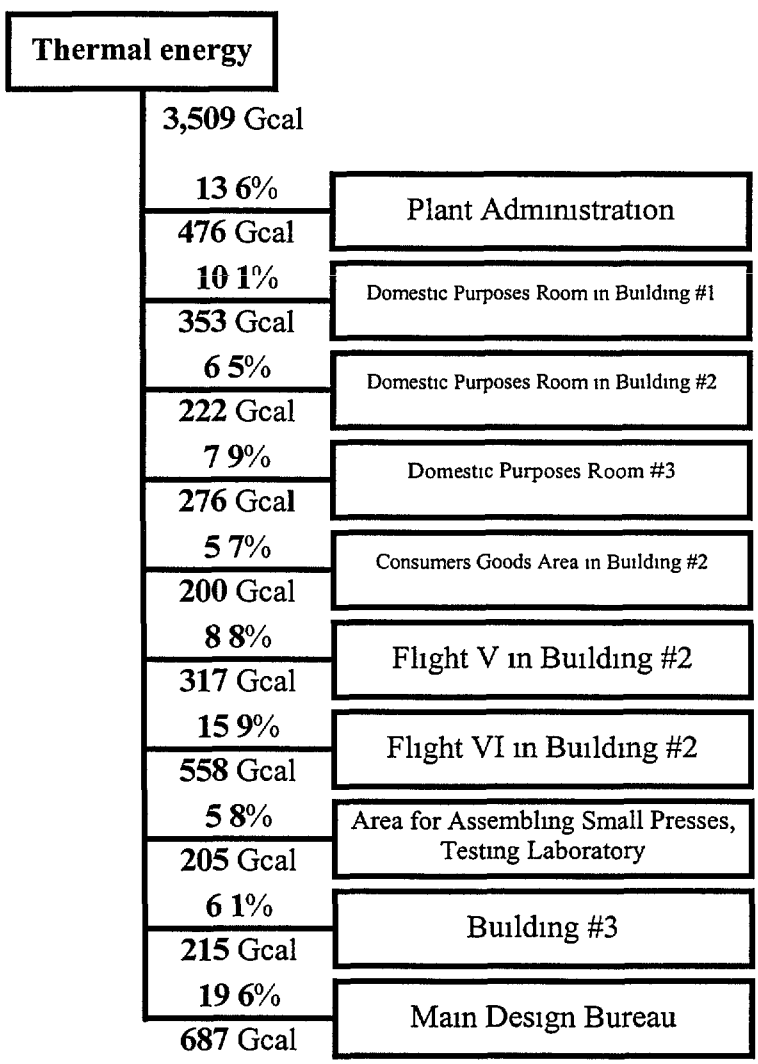


Fig 5 10 Balance of thermal energy consumption at OJSC "Presmash"

6 PREVIOUS ENERGY IMPROVEMENTS

Some work is in progress at the plant concerning implementation of energy conservation measures

- A plan of measures aimed at saving fuel-and-energy resources has been worked out
- A plan of decentralization of the compresses air supply system has been worked out At the painting area and at the consumers goods area two independent compressors were installed
- In 1996 the idling high-voltage transformers were disconnected from the electric power supply system Instead of four transformer substations two are connected at the present time
- Thermal insulation was repaired on the main steam pipelines, hot water supply pipelines and condensate ducts
- In 1996 *DKVR-6,5-13* Boiler was connectd to the water-heating operation mode
- Components are produced using the proper-size machines, so as to consume the least amount of electric power
- In the boiler-house there are installed two condensate tanks and a new steam pipeline

The main problem that remains is absence of broad-scaled and continuous efforts aiming at energy saving The majority of the measures aimed at energy conservation were implemented on an irregular basis and in conditions of no energy management system available That is why a lot of energy conservation opportunities remained in the process of the current operation un-nototiceable At the plant there is also no engineer responsible for energy saving, which makes the work in relation of energy saving more complicated

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 1,258,500 kW h (16 3 per cent of the total consumption in 1997), that of natural gas by 501,600 m^3 (35 8 per cent) Taking into account the infra-red heating systems to be introduced into practice, the natural gas saving will amount to 1,568,600 m^3 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 Organization of an 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 enervy 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 *7,723,245* kW h of electric power, ***160,000*** m^3 of drinking water and ***1,402,000*** m^3 of fuel (gas) 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	– ***386,160*** kW h
2) Gas	– ***70,100*** m^3
3) Water	– ***8,000*** m^3
Project implementation costs	– USD ***33,500***
Yearly saving of costs	– S_{costs} = USD ***27,200***
Simple payback period for the project is	– ***1 2*** years

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

ECO #2 Adjustment of the operation modes of the boiler aggregates

To meets the needs in thermal energy, *3* types of boilers are used at the plant *DE-6,5-13* – a steam boiler, *DKVR-6,5-13* (that was redesigned into a water-heating boiler), *DKVR-10-13* – a redundant boiler 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

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	$S_{gas\ nat.\ units}$ = *140,000* m^3
Yearly gas saving	S_{gas} = USD *13,860*
Commissioning costs	$Commis_{costs}$ = USD **6,500**
Simple payback period is	*0 47* years (6 months)

For more details in regard of this proposal see Appendix A, ECO #2

ECO #3 Redesigning of the system for hot water preparation

The current system for hot water preparation includes a steam boiler of ***DE-6,5-13*** type that produces steam with the following parameters ***P = 5 0*** kgf/cm^2 and temperature t^0 = *151* °C

This steam is supplied into steam-to-water heat excganger and then into the distributing tanks of the system for hot water supply for the buildings

The energy audit results have shown that under the current system of hot water preparation there are thermal energy losses that are accounted for by frequent starts-shutting-downs of the steam boiler, its low efficiency

It is proposed to change the scheme and the set of the equipment for hot water preparation For that, as the thermal energy source a *100*-kW boiler operating in the temperature range *95* to *70* °C with the efficiency not lower than *92*% should be installed

Saving of natural gas	–	S_{gas} = *28,070* m^3
Saving of electric power will be	–	S_{power} = *28,200* kW h
Yearly saving	–	USD *4,020*
Commissioning costs	–	$Commis_{costs}$ = USD *9,000*
Simple payback period	–	*2 2* years

For more details concerning this proposal see Appendix A, ECO #3

ECO #4 Thermal insulation of the steam pipelines and hot water pipelines

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

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

Yearly saving will be	–	*118,700* m^3 of natural gas
Yearly costs saving	–	S_{costs} = USD *15,021* year[1]
Commissioning costs	–	$Commis_{costs}$ = USD *4,677*
Simple payback period	–	*0 3* year (4 months)

For more details concerning this proposal see Appendix A, ECO #4

ECO #5 Automation of the reactive power control

At the plant there are operated devices for the reactive power compensation the total installed capacity of which is *8,380* kVA, including here those on the side of *0 4* kV – *7,690* kVA, *39* units, and those on the side of *6* kV – *690* kVA, they are not equipped with the systems for automatic control of the supplies power, which results in the average weighted power factor in the electric power supply for the plant being significantly lower than the value determined by the project ($cos\phi$ = *0 975* on the side of *0 4* kV with taking into consideration the compensation, and

0 94 on the side of *6* kV), and it is, according to the plots made by the plant in regard of the monthly loads for 1997 $cos\phi = 0\ 652$ to *0 999* (Appendix C)

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

Yearly electric power saving	– S_{power} = *228,000* kW h
Yearly costs saving	– S_{costs} = USD **6,860** per year
Commissioning costs	– $Commis_{costs}$ = USD **8,000**
Simple payback period	– *1 17* years

For more details concerning this proposal see Appendix A, ECO #5

ECO #6 Implementation of energy 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 (*35* units) and ***DRL-250***-type (*15* units) Apart of the territory of the plant adjoining to the production buil,dings is lit with ordinary incandescent lamps with the capacity of *500* W and *1,000* W The system of the internal lighting of the production area of the plant includes *110* illuminants with ***DRL-1000*** type lamps, *140* illuminants with ***DRL-700*** type lamps, *380* illuminants with ***DRL-400*** type lamps, *65* illuminants with ***DRL-250*** type lamps, *109* illuminants with incandescent lamps with the capacity of *300* to *500* kW and *110* illuminants with luminescent lamps The total installed capacity of the lighting fixture for the internal lighting in the production rooms is *480* kW

Taking into consideration that more than a half of the capacity is associated with these lamps, 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 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

Yearly saving of electric power will be	– S_{power} = *78,267* kW h
Yearly saving of costs	– S_{costs} = *3,443* yr[1]
Commissioning costs	– $Commis_{costs}$ = USD *8,275*
Simple payback period	– *1 9* years

For more details concerning this proposal see Appendix A, ECO #6

ECO #7 Improvement of the operation efficiency of the drying furnaces in the foundry

Drying of moulds and bars is performed in the foundry in chamber furnaces with an immovable bottom The drying is done by the products of combustion of natural gas that is burned in the dryer of bars - by means of *2* burners with the gas flow-rate of *40* m³/h, in a two-chamber dryer for moulds - by means of 4 burners with the gas flow-rate of *90* m³/h The combustion process is controlled manually by changing the temperature in the chamber The gas-to-air ratio cannot be controlled The study of the state of the gates showed that they are closed not tightly leaving a gap of ≈ *80* mm, the gate panels have no thermal insulation inside

It is proposed to repair the chamber gates, to provide their operation mode adjustment and organize monitoring of the combustion parameters in the furnaces for burning natural gas using for that combustion analyzer of ***ENERAC*** or ***BACARACH*** type

Gas saving will be – S_{gas} = *55,370* m³

Yearly saving of costs – S_{costs} = USD *5,482*

Commissioning costs – $Commis_{costs}$ = USD *7,500*

Simple payback period – *1 37* years

For more details concerning this proposal see Appendix A, ECO #7

ECO #8 Automation of the system for metering energy resources consumption

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

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 *3* points, commercial metering of gas consumption - in *2* points, that of hot water - in *3* points, of drinking water - in one point

Technical metering of electric power will be provided in *40* points, technical metering of hot water for processing needs – in *6* points, that of compressed air – in *4* points, gas – in *4* 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

So, according to the data for energy consumption in 1997, the saving of natural gas will be *70,100* m^3, that of electric power – *386,200* kW h, water – *8,000* m^3

Yearly saving of costs – S_{costs} =USD *33,500*

Commissioning costs – $Commis_{costs}$ = USD *65,000*

Simple payback period is – *1 9* years

For more detailes concerning this measure see Appendix A, ECO #8

ECO #9 Introduction of infra-red gas-fire heating systems in production buildings at the plant

They use air radiator stream heating of production buildings combined with the приточной вентиляцией The total number of the heated buildings is *11*, their total volume is *757,000* m^3 and the total consumption of thermal energy is *12,000* Gcal It should be noted that the maximum need at the plant for heat, with taking into account the heat for the dwelling houses and canteen included into the system, is *26* to *30* Gcal/h However, the boiler-house does not provide the said amount of the needed heat, its maximum production capacity is *16* Gcal/h So, in workshops electric heating is used It was found from analysis of the plots of electric loading at the plant for 1996-1997, a clearly evident winter maximum exists accounted for by addition of the load associated with starting electric heating in 1997 in January-March, November-December for the purposes of electric heating *1,022,000* кkW h were used and USD *44,300* were paid to the energy supplying company Though the required temperature of the air was not provided in the workshops A similar data concerning the energy efficiency are the amount of natural data is *141,000* m^3 that cost USD *14,000*

It is proposed to install in Buildings # 1, 2, 3 and 6 infra-red gas-fire heating systems

Saving of natural gas will be	– S_{gas} = *1,686,400* m³
Yearly saving of coasts of energy resources	– S_{costs}= USD *200,534*
Costs of commissioning the heaters	– $Commis_{costs}$ = USD *48,800*
Simple payback period is	– *0 24* year

For more details concerning this proposal see Appendix A, ECO #9

ECO #10 Optimization of the system for cooling the compressor plants

The air source for the plant if the central compressor station with air compressors Currently, as the need for production of compressed air decreased, only one compressor is in use, usually of *VP-50/8*-type, cooling of which requires *6* m³/h of water The compressor station cooling system is designed on the total cooling water flow-rate of *60* m³/h and it consists of two loops Loop *I* – *a* service tank – a water pump of *6K8*-type with the production capacity of the electric drive equal to *22* kW h, productivity of *60* m³/h – compressor– accumulating reservoir of *25* m³, Loop *II* accumulating reservoir – water pump of *6K8*-type – spray-cooling pond – a service tank The pump cycle of Loop *I* is a continuous for *9* hours per day, that for the pump in Loop *II* switches on for work for *15* min to empty the accumulating tanks every *40* min

It is proposed to make the parameters of the pump in Loop *I* match the real need of the compressor station, for that the pump of **K8/18** with the following parameters the maximum production capacity is *G* = *15* m³/h, the power capacity of the electric drive is *P* = *1 5* kW, which will allow to decrease the consumption of electric power for the purposes of cooling the compressor station with the pumps in Loops *I* and *II*

Total saving of electric power	– S_{power} = *35,784* kW h
Yearly saving of costs	– S_{costs} = USD *1,575*
Commissioning costs	– $Commis_{costs}$ = USD *270*
Simple payback period is	– *0 17* years (*2* months)

For more details concerning this proposal see Appendix A, ECO #10

ECO #11 Monitoring and optimization of the capacity of the electric devices

According the data for 1997, the basic manufacture consume about *69* per cent of the total amount of the electric power consumed by the plant, which is *5,309,000* kW h per year that cost USD *233,000*

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 power on Feeder #5 supplying power into the pattering workshop and into the repair and maintenance workshop, the installed designed capacity of the motors is used on *15* to *30* per cent

It is proposed to introduce at the plant operation control of the power that is actually consumed by the electric equipment 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 load of motors, analyze their efficiency and organize their planned replacement with more efficient ones 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

Yearly saving	- *116,000* kW h

Decreasing of energy costs	-	USD **5,104**
Commissioning costs	-	USD **4,500**
Simple payback period is	-	*0 17* years (*2* months)

For more detailed information concerning the proposal see Appendix A ECO #11

ECO #12 Thermal insulation of the hot water accumulating tank

In the boiler-house of the plant a hot water accumulating tank is installed with the volume of V = *22 8* m^3 that performs the function of the deaerator of the stream boiler and is also used for condensate collecting, The total external area of ha tank is F = *63 0* m^2 Currently the tank is not insulated The temperature of the external surfaces of the tank varies from *60* to *80*°C There are losses of heat into the environment through the non-insulated tank walls

It is proposed to provide insulation of the tank by spraying foam polyurethane with its covering with the aluminum paint followed, which will decrease the thermal losses into the environment by *90* **to** *95* per cent

Gas saving will be	–	*19,290* m^3/year
Yearly saving	–	USD *1,910*
Commissioning costs	–	USD *756 0*
Simple payback period is	–	*0 4* year

For more details concerning this proposal see Appendix A, ECO #12

8 ENVIRONMENTAL IMPACT OF 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 – $S_{1_g} = 70,100$ m³/year,
ECO #2 – $S_{2_g} = 140,000$ m³/year,
ECO #3 – $S_{3_g} = 28,000$ m³/year,
ECO #4 – $S_{4_g} = 118,700$ m³/year,
ECO #7 – $S_{7_g} = 55,400$ m³/year,
ECO #8 – $S_{8_g} = 70,100$ m³/year,
ECO #9 – $S_{9_g} = 1,067,000$ m³/year,
ECO #12 – $S_{12_g} = 19,300$ m³/year,

The total saving of natural gas will be

$$S_{totalgas} = S_{1_g} + S_{2_g} + S_{3_g} + S_{4_g} + S_{7_g} + S_{8_g} + S_{9_g} + S_{12_g} =$$

$$= 70,100 + 140,000 + 28,000 + 118,700 + 55,400 + 70,100 + 1,067,000 + 19,300 =$$

$$= 1,568,600 \text{ m}^3\text{/year}$$

When natural gas is burned, the carbon oxide s CO and nitrogen oxides NO_x 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 and of the combustion furnace (Appendix C), they showed that the emissions are as follows

- for the carbon oxide
  - from the boiler $M_{CO_B} = h_{CO_B} \ (S_{totalgas} - S_{7_g}) = 0\ 116 \ \ 1,513\ 2 = 175\ 5$ кг,
  - from the furnace $M_{CO_F} = h_{CO_F} \ S_{7_g} = 0\ 206 \ \ 55\ 4 = 11\ 4$ кг,

  Total $M_{CO} = 175\ 5 + 11\ 4 = 187$ кг,
- for nitrogen oxides
  - from the boiler $M_{NOx_B} = h_{NOx_B} \ (S_{totalgas} - S_{7_g}) = 0\ 234 \ \ 1,513\ 2 = 354$ кг,
  - from the furnace $M_{NOx_F} = h_{NOx_F} \ S_{7_g} = 0\ 19 \ \ 55\ 4 = 10\ 5$ кг,

  Total $M_{NOx} = 354 + 10\ 5 = 365$ кг,

where h_{CO}, h_{NOx} – the 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 – $W_1 = 386,000$ kW h,
ECO #3 – $W_3 = 28,200$ kW h,

ECO #5 – $W_5 = 228,000$ kW h,
ECO #6 – $W_6 = 78,300$ kW h,
ECO #8 – $W_8 = 386,200$ kW h,
ECO #10 – $W_{10} = 35,800$ kW h,
ECO #11 – $W_{11} = 116,000$ kW h,

The total saving of electric power will be

$$W_{total} = W_1 + W_3 + W_5 + W_6 + W_8 + W_{10} + W_{11} =$$

$$= 386,000 + 28,200 + 228,000 + 78,300 + 386,200 + 35,800 + 116,000 = 1,258,500 \text{ kW h/yr}$$

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

The 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		5 54	5 54
Carbon oxide, tonne	0 187	0 63	0 82
Nitrogen oxides, tonne	0 365	2 77	3 14
Sulfur oxides, tonne		12 46	12 46

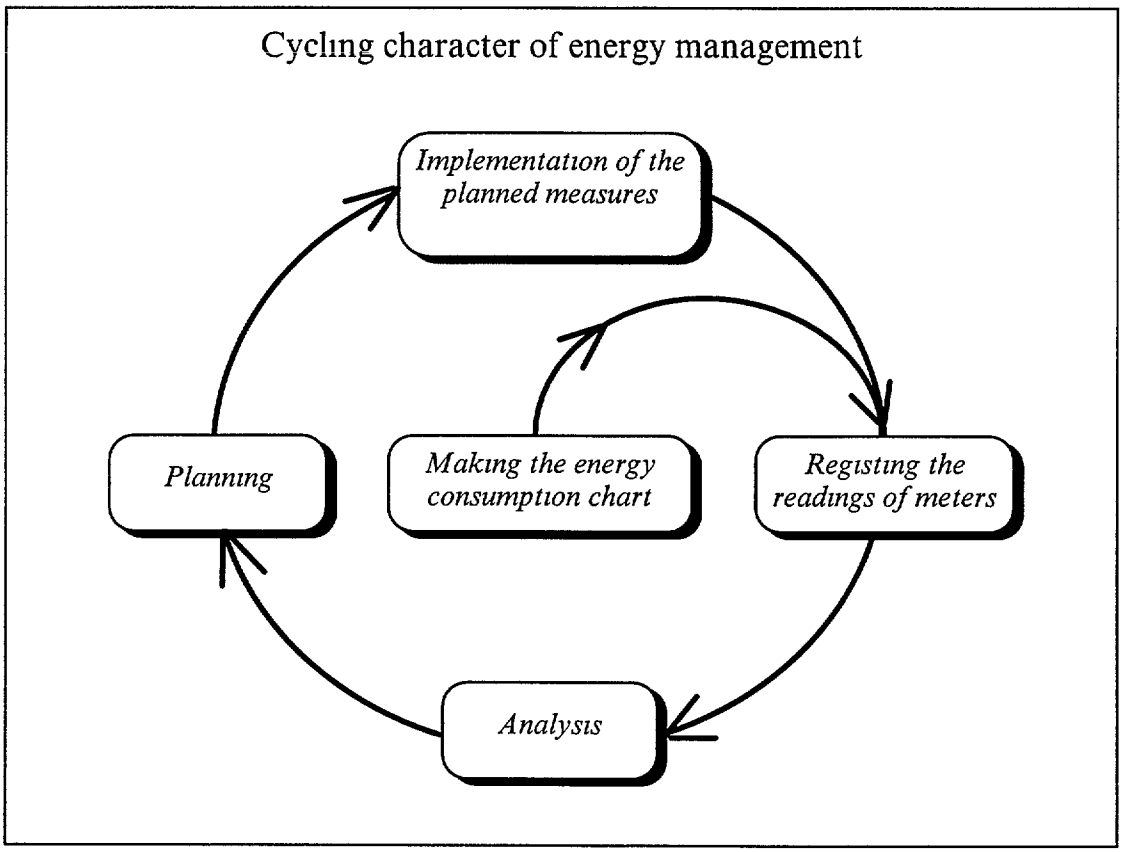
So, implementation of the proposed measures will bring to decreasing the emissions of hard particles into the atmosphere by *22* tonnes, which, of course, will be of the positive effect on the ecological environment in the City of Odesa

APPENDIX A ENERGY CONSERVATION OPPORTUNITIES (ECOs)

ECO #1 ORGANIZATION OF EENRGY MANAGEMENT

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 *7,723,245* kW h of electric power, *160,000* m^3 of drinking water and *1,402,000* 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 – $7{,}723{,}245 \times 0\ 05 = 386{,}160$ kW h
2) gas – $1{,}402{,}000 \times 0\ 05 = 70{,}100$ m^3
3) water – $160{,}000 \times 0\ 05 = 8{,}000$ m^3

Calculation of the yearly saving of costs

1 If *1* kW h of electric power costs USD *0 044,* then saving of the costs will be

$$386{,}160 \times 0\ 044 = \text{USD } 17{,}000$$

2 If *1* m^3 of gas costs USD *0 083,* saving of the costs will be

$$70{,}100 \times 0\ 083 = \text{USD } 5{,}800$$

3 If *1* m^3 of water costs USD *0 55*, then saving of the costs will be

$$8{,}000 \times 0\ 55 = \text{USD } 4{,}400$$

The total saving of the energy costs is

$$17{,}000 + 5{,}800 + 4{,}400 = \text{USD } 27{,}200$$

Commissioning costs

The world practice shows that the costs of implementation of energy management are planned and they are *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 USD *670,000*, the total costs of implementation of energy management will be

$$670{,}000 \times 0\ 05 \cong \text{USD } 33{,}500$$

Estimation of the simple payback period

Projects implementation costs	– USD *33,500*
Yearly saving of costs	– USD *27,200*
Simple payback period is	– *33,500 / 27,200 = 1 2* years

ECO #2 ADJUSTMENT OF OPERATION MODES OF THE BOILER AGGREGATES

Description of the opportunity

To meets the needs in thermal energy, *3* types of boilers are used at the plant *DE-6,5-13* – a steam boiler, *DKVR-6,5-13* (that was redesigned into a water-heating boiler), *DKVR-10-13* – a redundant boiler 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 air consumption ratio is checked regularly 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 infiltration, does not allow to speak with the full right about the optimal combustion mode Control of how close the combustion mode is close to the optimal one is performed by the subjective acceptation of the color of the flame by the furnace operator

The above said is proved by the data of measuring the efficiency of burning natural gas ion the boiler of DE-6,5/13-type that was done by means of ***BACHARACH*** combustion analyzer (Appendix C)

As it was found from the measurements results, the amount of oxygen in the exhaust gases duct is *16 3* to **19** *7* per cent, the exceeding air coefficient is *3 62* to *4,99*, the temperature of the exhaust gases after the boiler is *215*°C, that before the exhaust fan is *69*°C, the efficiency of gas combustion is *69 5* to *71 5* per cent (without taking into consideration the temperature of the blown air and the economizer)

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 utilizing fuel, thermal energy and electric power", in 1997 the plant produced ***3,509*** Gcal, for the industrial and domestic needs - ***4,850*** Gcal, with that the actual consumption of fuel was G = ***1,282*** tonnes of the conventional fuel or ***1,115,000*** m^2 of natural gas Due to the manufacturer's certificate on the boilers of ***DKVR-6,5-13***, ***DE-6,5-13***, and ***DKVR-10-13*** types equipped with an economizer, shall have the efficiency η = *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 averaged value of the boiler efficiency is η_{Baver} = *77 0* % at the actual specific consumption of *185 6* kg of the conventional fuel per *1* Gcal

Implementation of the said measure will decrease the specific rate of consumption by $b \approx$ *12 5*% and it will make it equal to *162 34* kg of the conventional fuel per *1* Gcal, improve the averaged weighted boiler efficiency up to *88* per cent

Saving of gas in the natural units is

$$S_{gas} = G \quad b = 1,115 \quad 0\ 125 = 140,000 \text{ m}^3$$

Calculation of the yearly saving of costs

Saving of the costs, if *1,000* m^3 cost USD *99*, will be

$$S_{costs} = S_{gas} \quad 83 = 140 \quad 99 = \text{USD } 13,860 \text{ yr}^{1}$$

Commissioning costs

Expenditures to purchase *ENERAC - 2000* combustion analyzer

S_1 = USD *5,000*

Transportation and shipping S_2 = USD *1,500*

Total $S_{TOTAL} = S_1 + S_2 = 5{,}000 + 1{,}500 =$ USD *6,500*

Estimation of the simple payback period

Yearly gas saving – $S_{gas\ costs}$ = USD *13,860* per year

Commissioning costs – $Commis_{costs}$ = USD **6,500**

Simple payback period is

$SPP = S_{TOTAL}/S_{costs} = 6{,}500/13{,}860 = 0\ 47$ years (*6* months)

ECO #3 REDESIGNING THE HOT WATER PREPARATION SYSTEM

Description of the opportunity

The current system for hot water preparation includes a steam boiler of ***DE-6,5-13***-type that produces steam with the following parameters $P = 5\ 0$ kg s/cm^2 and the temperature $t^\circ = 151$°C

This steam comes into a steam-to-water heat exchangr and then into the service tanks in the hot water supply system for the buildings

As it was found in the energy audit, providing the current system for hot water preparation thermal losses are present, they are accounted for by frequent starts and shut-downs of the steam boiler, low loading of the boiler low efficiency

It is proposed to change the scheme and the types of the equipment in the system for hot water preparation For that, a ***100***-kW boiler should be installed operating in the temperature range of ***95*** to ***70*** °C and having the efficiency of not lower than ***92*** per cent

- the coolant from the boiler goes into the water-water plate heat exchanger with the corresponding thermal conductivity The electric motors of the circular pump and the ventilator of the burner consume not more than ***3*** kW,
- cold water is heated in the plate water heater up to $t^\circ_{hw} = 60$°C and then it goes into the hot water accumulating tanks that are installed in the buildings

The steam boiler should be used to compensate for the deficit of the thermal energy on the areas not included to be covered in ECO #10

Calculation of the yearly energy saving

Consumption of thermal energy for the hot water supply purposes can be determined from the formula

$$Q_{hws} = n \quad C_{water}\,(t_{hot} - t_{cold}) \quad (m_{shower}\ \ g_{hot/shower} + m_{crane}\ \ g_{hot/crane}) \quad \tau \quad 10^{-6}, \text{ Gcal},$$

where n – the number of the working days in a year, $n = 254$ days,

C_{water} – the thermal capacity of water, kcal/(1 °C), $C_{water} = 1\ 0$ kcal/(1 °C),

$m_{shower}\ \ m_{crane}$ – the calculated numbers of the users of shower and cranes,

$g_{hot/shower}, g_{hot/cranes}$ – the rate for consuming hot water for showers and cranes, l/person, $g_{hot/shower} = 270$ l/person, $g_{hot/crane} = 60$ l/person ,

t_{hot}, t_{cold} – calculated temperatures of the hot and cold water in the non-heated period, °C, $t_{hot} = 60$°C, $t_{cold} = 15$°C,

τ – time for washing, hour, $\tau = 1$ hour

$$Q_{hws} = 254 \quad 1\,(60 - 15) \quad (30 \quad 270 + 12 \quad 60) \quad 1 \quad 10^{-6} = 100\ 8 \text{ Gcal}$$

Consumption of hot water is ***8,820*** l per day, consumption of thermal energy of the heated water is $Q = 0\ 31$ Gcal per day

DE-6,5-13 boiler operates ***3*** hours a day, ***2*** hours of those are used for kindling and ***1*** hour is used directly for water heating in a boiler with the efficiency $\eta_1 = 70\%$ and the specific heat consumption $b_1 = 177\ 46$ m^3/Gcal

It is proposed to install a water heating boiler of *KV*-0,1 type having the thermal capacity ***100*** kW, efficiency $\eta_2 = 92\ \%$ and the specific consumption $b_2 = 134\ 88$ m^3/Gcal,

Saving of natural gas when kindling the boilers is

$S_{gas/kindl} = (B_{kindl1} - B_{kindl2}) \quad n = (250 - 50) \quad 140 = 28{,}000$ kg of the conventional fuel or

24,350 m³,

where B_{kindl1} and B_{kindl2} – rates of the conventional fuel for kindling, respectively, of the boiler of DE-6,5-13 type after *21* hours of its idling and of the boiler of KV-0,1 type after its *18* hours of idling

$B_{kindl1} = 200$ kg of the conventional fuel

$B_{kindl2} = 50$ kg of the conventional fuel,

n – the number of the working hours in a year, $n = 140$ days

Saving of natural gas while heating water is

$$S_{wh} = Q_{hws} \quad 1\ 1 \quad (b_1 - b_2) = 100\ 8 \quad 1\ 1 \quad (177\ 46 - 134\ 88) = 4{,}720 \text{ m}^3$$

Saving of natural gas is $S_{gas} = 24{,}350 + 4{,}720 = 28{,}070$ m³

DE-6,5-13 boiler operates *3* hours a day, with that *DN-10* exhaust fan is operating having the capacity of the electric drive $N_{gb1} = 40$ kW, the power consumed is *18* kW

Consumption of electric power by the circular pump and by the fan of the burner at *KV-0,1* boiler is not more than $N_{gb2} = 3$ kW

Saving of electric power will be

$$W = (N_{gb1} - N_{gb2}) \quad 3 \quad n = (40 - 3) \quad 3 \quad 254 = 28{,}200 \text{ kW h}$$

Calculation of the yearly saving of costs

Saving of the costs of natural gas, if *1* m² costs USD *0 099,* is

$$S_{g_g} = Э_g \quad 0\ 099 = 28{,}070 \quad 0\ 099 = \text{USD } 2{,}780$$

Saving of electric power, if *1* kW h costs USD *0 044* is

$$S_{g_{power}} = W \quad 0\ 044 = 28{,}200 \quad 0{,}044 = \text{USD } 1{,}240$$

The total saving of the costs after implementation of the measure

$$2{,}780 + 1{,}240 = \text{USD } 4{,}020$$

Commissioning costs

The cost of the boiler and water heater	–	USD *6,000*
The cost of the designing works	–	USD *1,000*
The cost of the installation works	–	USD *2,000*
TOTAL	–	USD *9,000*

Estimation of the simple payback period

Yearly saving	– USD *4,020*
Commissioning costs	– USD *9,000*

<u>Simple payback period</u> is

$$9{,}000/4{,}020 = 2\ 2 \text{ years}$$

ECO #4 THERMAL INSULATION OF THE STEAM DUCTS AND HOT WATER SUPPLY DUCTS

Description of the opportunity

The fulfilled analysis of the steam distribution system, there was found that some steam pipelines, branches and the piping part of the hot water supply system have no thermal insulation

The data concerning the broken insulation and of the non-destroyed pipe system were received while doing measurements at the enterprise and they are given in Table A 4 1

Table A 4 1

Pipeline use	Total length, m	Diameter, mm	Number of flanges	Number of valves	t°C
1 Steam pipeline	54	250	8	1	160
2 Steam pipeline	15	200	–	–	160
3 Steam pipeline	14	125	10	1	160
4 Steam pipeline	39	100	10	2	160
5 Hot water	8	200	–	–	60
6 Hot water	40	150	–	–	60
7 Hot water	17	100	–	–	60
8 Hot water	47	50	–	–	60

The efficiency of the boiler, as the made measurements showed that, is *87* per cent, the efficiency of the system for steam distribution is *78* per cent Steam consumption at the pressure of *4* kg/cm^2 is *5* tonnes/hour, and the steam boiler operating all the year round in average it is *70* per week, so it makes *52* weeks per year

It is proposed to insulate completely the steam pipeline network and the hot water supply network

The thickness of the insulating tape shall have a thickness depending on the tube diameter and its purpose (Table A 4 2)

Table A 4 2

Purpose	Diameter, mm	Insulation thickness, mm
1 Steam	100 to 250	100
2 Hot water	200	92
3 Hot water	50 to 150	42

Calculation of the yearly energy saving

We determine the thermal losses for the insulated and non-insulated pipelines in accordance with the approach given in the Methodical instructions concerning determination of the losses of fuel and energy resources ***РД5 ЕДИВ 015 - 008 - 94,*** issued by the Ministry for Machine Building in 1994, Lviv City, Ukraine

The losses of thermal energy by the non-insulated pipelines are determined be means of the formula

$$Q_{LOW} = q_{LOW} \quad L_0 \quad k \text{ , kcal/h,}$$

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

k – a correcting coefficient whose value depends on the temperature in the air and on the difference between the temperatures of the pipeline walls and of the air,

L_0 – the reduced length of the pipeline, m

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

n – the number of valves on the area, pieces,

f – the number of flanges on the area, pieces

For Pipeline #1 from Table 1

$$Q_{non\ ins1} = 1{,}500 \quad (54 + 1 + 4) \quad 0\ 96 = 84{,}960 \text{ kcal/h}$$

The further calculations are made in a similar way, the results are summed up in Table A 4 3

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

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

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

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

t_2 – the temperature of the air, °C,

a – a correcting coefficient depending on the insulation thickness, coefficient of the thermal conductivity, coefficient of the insulating and on the temperature difference between the coolant and the air If the insulation thickness is ***100*** mm and the temperature difference is up to ***300***°C, then it is set that $a = 1$,

b – a correcting coefficient taking into account influence of the wind (when the wind velocity is above ***5*** m/s)

Currently, it is really to speak about decreasing the thermal losses in the thermal network by using up-to-date efficient sorts of thermally insulating materials, such as cellular plastic masses, for the steam pipelines, foam-based materials for the condensate ducts, etc with the coefficient of the thermal conductivity in the range of ***0 03*** to ***0 05*** kcal/(m h °C) We suppose for the insulating purposes to be used the said materials

For Pipeline #1 from Table A4 1

$$Q_{ins1} = 0\ 426 \quad (160 - 15) \quad 1 \quad 1\ 04 \quad 59 = 3{,}790 \text{ kcal/h}$$

The similar calculations were done for all the pipelines, the results a re given ion Table A 4 3

The net saving was estimated with taking into account the length of the pipeline, while the full one was gained taking into account the efficiency of the boiler and that of the steam distribution system

Table A 4 3

Pipeline #	Reduced length	Thermal losses without	Thermal losses with insulation	Net saving	Full saving
	L_0, m	$Q_{non\ ins}$, kcal/h	Q_{ins}, kcal/h	S_{net}, kcal/h	S_f, kcal/h
1	59	84,960	3,790	81,170	119,614
2	15	14,400	823	13,577	20,006
3	20	15,360	618	14,742	21,724
4	46	26,880	1,602	25,278	37,250
5	8	1,900	161	1,739	2,563
6	40	7,600	1,079	6,521	9,609
7	17	2,422	337	2,085	3,072
8	47	4,465	595	3,870	5,703
			Total	**148,982**	**219,541**

So, the yearly saving will be

$$S_{costs} = 219{,}541 \text{ kcal/h} \quad 70 \text{ h} \quad 52 \text{ weeks} \quad 10^{-6} = 799 \text{ Gcal/year,}$$

which is *118,700* m^3 of natural gas

Calculation of the yearly saving of costs

1 Gcal costs = USD *18 8*

Yearly saving in the pecuniary units

$$S_{costs} = 799 \quad 18\ 8 = \text{USD } 15{,}021$$

Commissioning costs

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

$$S_{ins} = L_{o6} \quad C_{ins\ 6} + L_{on} \quad C_{ins\ n} = 112 \quad 8 + 122 \quad 10\ 5 = \text{USD } 2{,}177,$$

where L_{o6} – the total reduced length of the hot water supply pipelines # 5, 6, 7, 8 in Table A 4 1, m

L_{on} – the total reduced length of the steam pipelines #1 to 4 in Table A 4 3, m,

$C_{ins\ 6}$, $C_{ins\ n}$ – the cost of *1* running meter of insulation respectively for the pipelines of hot water supply and the steam supply, USD /m

Costs of the installation works

$$C_{instal.} = \text{USD } 2{,}500$$

So, the total expected expenses are

$$C_{exp} = C_{ins} + C_{instal.} = 2{,}177 + 2{,}500 = \text{USD } 4{,}677$$

Estimation of the simple payback period

Yearly saving of costs – S_{costs} = USD *15,021* per year

Commissioning costs – $Commis_{costs}$ = USD *4,677*

Simple payback period

$$SPP = C_{exp}/S_{costs} = \text{USD } 4{,}677/15{,}021 = 0\ 3 \text{ year } (4 \text{ months})$$

ECO #5 AUTOMATION OF CONTROLLING THE REACVTIVE POWER PLANTS

Description of the opportunity

At the plant there are operated devices for the reactive power compensation the total installed capacity of which is *8,380* kVAr, including here those on the side of *0 4* kV – *7,690* kVAr, *39* units, and those on the side of *6* kV – *690* kVAr, they are not equipped with the systems for automatic control of the supplies power, which results in the average weighted power factor in the electric power supply for the plant being significantly lower than the value determined by the project ($cos\phi = 0\ 975$ on the side of *0 4* kV with taking into consideration the compensation, and *0 94* on the side of *6* kV), and it is, according to the plots made by the plant in regard of the monthly loads for 1997 $cos\phi = 0\ 652$ to *0 999* (Appendix C) The plot for the load made for the power supply line to the pattering workshop from the *0 4*-kV Distribution Station in the compressor station for the 24 hours from April 14 to April 15,1998 (Appendix C) showed that the natural power factor $cos\phi$ varies in the range of $cos\phi = 0\ 5$ to *0 99* The low value of the power factor brings to losses of electric power Besides, as it was found after the measurements, there takes place re-compensation, which results in voltage rising from *216 8* to *241 3* V in the modes of the maximum loads

It is proposed to provide means for compensating the reactive power by the electric power automatic control system

Calculation of the yearly energy saving

Decreasing of losses in the electric lines by increasing the power factor of the electric power consuming devices will be

$S = k\ \ (W_{r1} - W_{r2}) = 0\ 08\ \ (4{,}070 - 1{,}220) = 228{,}000$ kW h,

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

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

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

The figures for consumption of electric power by the OJSC "Presmash" in 1997 are shown in Table A 5 1, they were received from the plant

Table A 5 1

Parameter	Measure unit	Parameter value	
		actual in 1997	after implementation of the measure
1 Consumption of active power	kW h x 10^6	5 309	5 309
2 Consumption of reactive power	kVAr x 10^6	4 07	1 22
3 Power factor, tgϕ	–	0 7666	0 2309
4 Payment for the reactive power	USD	9,800	2,940

Implementation of the proposal will decrease losses of electric power in electric lines by

228,000 kW h, besides the payment for the reactive power consumed will go down (see Table A 5 1) by USD *6,860*

Commissioning costs

To provide compensation of the reactive power to the designed value of the power factor $tg\phi$ = *0 23*, at the plant, taking into consideration the actual load, there should be installed systems for controlling the cosinus capacitors with the total power of 860 kVAr The cost of the equipment and installation works is USD ***8,000***

Estimation of the simple payback period

Yearly saving of costs – S_{costs} = USD ***6,860*** per year

Commissioning costs – $Commis_{costs}$ = USD ***8,000***

Simple payback period is

$$SPP = Commis_{costs}/S_{costs} = 8{,}000/6{,}860 = 1\ 17 \text{ years}$$

ECO #6 INTRODUCTION OF EFFICIENT LIGHTING 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 (*35* units) and ***DRL-250***-type (*15* units) Apart of the territory of the plant adjoining to the production buil,dings is lit with ordinary incandescent lamps with the capacity of *500* W and *1,000* W The system of the internal lighting of the production area of the plant includes *110* illuminants with ***DRL-1000*** type lamps, *140* illuminants with ***DRL-700*** type lamps, *380* illuminnats with ***DRL-400*** type lamps, *65* illuminnats with ***DRL-250*** type lamps, *109* illuminants with incandescent lamps with the capacity of *300* to *500* kW and *110* illuminnats with luminescent lamps The total installed capacity of the lighting fixture for the internal lighting in the production rooms is *480* 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-100*** type it is correspondingly *10,000* Lm and *2,400* hours

Taking into consideration that more than a half of the capacity is associated with these lamps, 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 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-250-3 those are *6,000* hours and *9,000* Lm

Calculation of the yearly energy saving

"External lighting"

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

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

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

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

$cos\varphi = 0\ 98$

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

The amount of the electric power that is consumed by *35* illuminants for a year, providing that they are switched in average *10* hours per day

$$P_1 = P_{ill.1} \quad n_1 \quad F_1,$$

where $n_1 = 35$ – it is the number of the illuminants,

$F_1 = 10 \quad 365 = 3,650$ hours – the yearly fund of the operation time for an illuminant

$$P_1 = 0\ 475 \quad 35 \quad 3,650 = 60,681 \text{ kW h}$$

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,

$cos\varphi = 0\ 98$

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

The amount of electric power consumed by ***35*** illuminants for a year, if to switch them in average for ***10*** hours a day is

$$P_2 = P_{ill.2}\ \ n_1\ \ F_1 = 0{,}279\ \ 35\ \ 3{,}650 = 35{,}642 \text{ kW h}$$

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

$$S_{el.pow\,1} = P_1 - P_2 = 60{,}681 - 35{,}642 = 25{,}039 \text{ kW h}$$

The electric power of 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,

$cos\varphi = 0\ 98$

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

The amount of the electric power consumed by ***15*** illuminants for a year, if in average each is switched for ***10*** hours, is

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

where $n_2 = 15$ – the number of the illuminants,

$$P_3 = 0\ 298\ \ 15\ \ 3{,}650 = 16{,}315 \text{ kW h}$$

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

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

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

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

$cos\varphi = 0\ 98$

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

The amount of electric power consumed by ***15*** illuminants for a year, if in average each is switched for ***10*** hours per day is

$$P_4 = P_{ill\,4}\ \ n_2\ \ F_1 = 0\ 105\ \ 15\ \ 3{,}650 = 5{,}748 \text{ kW h}$$

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

$$S_{el.power\text{-}2} = P_3 - P_4 = 16{,}315 - 5{,}748 = 10{,}567 \text{ kW h}$$

"Internal lighting"

The amount of the electric power consumed by ***120*** 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 $n_3 = 120$ – the number of the illuminants,

$$P_5 = 0\ 475 \;\; 120 \;\; 1\ 095 = 62{,}415 \text{ kW h}$$

The amount of the electric power consumed by ***120*** illuminants with DNaT-250-3 lamps for a year, if in average each is switched for ***3*** hours per day, is

$$P_6 = P_{ill\,2} \;\; n_3 \;\; F_2 = 0{,}279 \;\; 120 \;\; 1095 = 36{,}660 \text{ kW h}$$

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

$$S_{el.power\text{-}3} = P_5 - P_6 = 62{,}415 - 36{,}660 = 25{,}755 \text{ kW h}$$

The amount of the electric power consumed by ***80*** 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

$$P_7 = 0{,}298 \;\; 80 \;\; 1{,}095 = 26{,}104 \text{ kW h}$$

The amount of the electric power consumed by ***80*** illuminants with *DNaT-100-3* lamps for a year, if each is switched in average for ***3*** hours per day, is

$$P_8 = P_{ill4} \;\; n_4 \;\; F_2 = 0\ 105 \;\; 80 \;\; 1\ 095 = 9\ 198 \text{ kW h}$$

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

$$S_{el.power4} = P_7 - P_8 = 26{,}104 - 9{,}198 = 16{,}906 \text{ kW h}$$

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

$$S_{TOTAL\,power} = 25{,}039 \text{ kW h} + 10{,}567 \text{ kW h} + 25{,}755 \text{ kW h} + 16{,}906 \text{ kW h} = 78{,}267 \text{ kW h}$$

Calculation of the yearly saving of costs

Saving costs in the pecuniary units, if ***1*** kW h costs at the plant USD ***0 044,*** is

$$S_{costs} = S_{TOTAL\,power} \;\; 0\ 044 = 78{,}267 \;\; 0\ 044 = \text{USD } 3{,}443 \text{ per year}$$

Commissioning costs

One *DNaT-250* lamp with the starting-up device costs - C_1 = USD ***35***
One *DNaT-100* lamp with the starting-up device costs - C_2 = USD ***30***
One *DRL-400* lamp costs - C_3 = USD ***6 5***
One *DRL-250* lamp costs - C_4 = USD ***5 5***
Commissioning costs $Commis_{costs}$ = USD ***35 55*** + USD ***30 95*** = USD ***8,275***

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} = USD ***3,443*** per year

<u>Simple payback period</u>

$SPP = Commis_{costs}/S_{costs} = [(C_1 - 2C_3)\ \ 55 + (C_2 - 2C_4)\ \ 95 / S_{costs} = [(35 - 2\ \ 6\ 5)\ \ 55 + (30 - 2\ \ 5\ 5)\ \ 95 / 3,443 = 1\ 9\ years$

ECO #7 IMPROVEMENT OF THE EFFICIENCY OF THE DRYING FURNACES IN THE FOUNDRY

Description of the opportunity

Drying of moulds and bars is performed in the foundry in chamber furnaces with an immovable bottom The drying is done by the products of combustion of natural gas that is burned in the dryer of bars - by means of *2* burners with the gas flow-rate of *40* m³/h, in a two-chamber dryer for moulds - by means of **4** burners with the gas flow-rate of *90* m³/h The combustion process is controlled manually by changing the temperature in the chamber The gas-to-air ratio cannot be controlled The study of the state of the gates showed that they are closed not tightly leaving a gap of $\approx$ *80* mm, the gate panels have no thermal insulation inside As it was shown by the results of measurements of parameters of the natural gas combustion in a two-chamber moulds (Appendix C), the efficiency of gas combustion η = *68 47* per cent, the coefficient of the exceedent air is α = *2 98* to *3 32*, the oxygen content in the combustion products is *14 3* to *15 0*, the temperature in the chamber is *314* to *271*°C, which shows a non-satisfactory organization of natural gas utilization

It is proposed to repair the chamber gates, to provide their operation mode adjustment and organize monitoring of the combustion parameters in the furnaces for burning natural gas using for that combustion analyzer of ***ENERAC*** or ***BACARACH*** type

Calculation of the yearly energy saving

As was found from the results of the energy audit, the main causes for the non-economical utilization of natural gas in the furnaces of the dryers are as follows

1) low efficiency of combustion of natural gas that is equal to η = *68 47*% – as the average value of three measured values Provision of a continuous control of the combustion process using combustion analyzers, if that corresponds to the operation mode chart, as well as elimination of the cause of the non-rational exceeding amount of the air and making its value equal to α = *1,15* (instead of the measured value α_a = *2 98* to *3 32*, will enable to improve the efficiency to *97* percent and to decrease consumption of natural gas by

$$B_G = \frac{B_{97}}{1\ 15}\left(1-\frac{1}{(2-\eta_\varphi)\ \eta_{nom}}\right) = \frac{274}{1\ 15}\left(1-\frac{1}{(2-0\ 6847)\ 0\ 97}\right) = 52{,}500\ \text{m}^3,$$

where B_{97} – consumption of natural gas for drying moulds, according to the statistical reported data included in Form #11 *мтп* "Report on utilization for boiler-houses and furnaces of fuel, thermal energy and electric power" for 1997 (in tonnes of the conventional fuel),

η_φ – the measures value of the efficiency of combustion of natural gas in the furnace, η_ϕ = *0 6847*,

η_{nom} – the nominal value of the efficiency of combustion of natural gas in the furnace, η_{nom} = *0,97*,

2) losses of heat through the insulation of the chamber gates As it was shown from the results of the energy audit, the chamber dryers are closed by the gates with the size of

4,000 × 2,800 × 100 – 2 units, and of *3,400 × 2,800 × 80 – 1* unit The gates shall be thermally insulated from inside - but there is no insulation

The thermal losses through the insulation of the gates of the chamber for drying moulds can be determined by means of the formula

$$Q_{B1} = F_{gate1}\ (q_{\varphi 1} - q_{nom.1})\ T_G = 11\ 2\ (4{,}600 - 1{,}230)\ 475 = 17{,}926{,}500\ \text{kcal},$$

where F_{gate1} – the area of the gate, m² We set it equal to *2 8 × 4 = 11 2* m²,

$q_{\varphi 1}$ – the actual specific thermal flux at the temperature of $t^0 = 350$°C through the double-gate of metal with an air gap between the panels, $q_{\varphi 1} = 4{,}600$ kcal/m² h,

$q_{nom\ 1}$ – the nominal specific thermal flux through the gate relining, $q_{nom} = 1{,}230$ kcal/m² h,

T_G – the number of the working hours of the furnace, we will determine it on the basis of the data about the loading the production equipment, $T_G = 475$ hours

Similarly, the thermal losses through the insulation of the chamber gate in the dryer0 for bars are as follows

$$Q_{B2} = F_{gate2} \quad (q_{\varphi 2} - q_{nom\ 2}) \quad T_G = 9\ 52 \quad (4{,}600 - 1{,}530) \quad 475 = 13{,}882{,}540 \text{ kcal},$$

or $2{,}520$ m³ of natural gas

$$F_{gate2} = 2{,}8 \times 3{,}4 = 9{,}52 \text{ m}^2,$$

3) thermal losses by heat radiation through the faulty sealing when the gate is closed can be determined using the formula

$$Q_{rad.} = G_s \left(\frac{T}{100}\right)^4 \cdot F_{open} \cdot f \quad T_G \quad 2 = 4\ 96 \left(\frac{573}{100}\right)^4 \quad 0\ 544 \quad 0\ 7 \quad 475 \quad 2 = 1{,}934{,}200 \text{ kcal},$$

or 350 m³ of natural gas,

where G_s – radiation coefficient, $G_s = 4\ 96$ kcal/m² h,

T – average temperature of the furnace, $T = 573$°K,

$F_{open.}$ – area of the gap resulting from failing to close the door tightly, $F_{open} = 0\ 544$ m²,

ϕ – the diaphragming coefficient, $\phi = 0\ 7$

The gas saving will be

$$S_{gas} = 52\ 5 + 2\ 52 + 0\ 35 = 55{,}370 \text{ m}^3$$

Calculation of the yearly energy saving

Saving of funds in the pecuniary units, if $1{,}000$ m³ cost USD 99, is

$$S_{costs} = S_{gas} \quad 99 = 55\ 37 \quad 99 = \text{USD } 5{,}482 \text{ per year}$$

Commissioning costs

The cost of the gate insulation – USD $1{,}000$

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

The cost of the combustion analyzer of *ENERAC* type – USD $6{,}500$

Estimation of the simple payback period

Yearly saving of costs – S_{costs} = USD $5{,}482$

Commissioning costs – $Commis_{costs}$ = USD $7{,}500$

Simple payback period is

$$SPP = Commis_{costs}/S_{costs} = 7{,}500/5{,}482 = 1\ 37 \text{ years}$$

With rising the loading level the saving will rise too

ECO #8 AUTOMATION OF METERING CONSUMPTION OF ENERGY RSOURCES

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 to three distribution devices *RP-1, RP-2* and *RP-3*, they have two inputs of ***6***-kV each At the production are distribution of the electric power is done through 16 transformer substations ***6/0 4*** kV with the total capacity of ***15,360*** kVA Commercial metering of electric power consumption is provided on the inputs at Distribution Substation #1 (*RP 1),* Distribution Substation #2 (*RP 2*), Distribution Substation #3 (*RP 3*) 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 ***TsT5000*** systems by connecting to the existing matrix of the primary transducers ITEK-210 is included into the State Measuring Instruments Register of Ukraine

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

Introduction into practice of **ITEK-x2x** allows the users to perform metering the consumption of energy resources with a high precision and pay for the used recourses not according to the fact but in proportion to the used area

ITEK-220, ITEK-320 are designed to be used in automatic systems for commercial and telemetric monitoring of the provided and consumed liquids, steam and thermal energy together

with any standard primary transducers for measurements of flow rate, temperature and pressure differences that have rated output parameters, at the suppliers' (Heat Power Plants, heat and power supply lines, boiler-houses) and at the consumers' (industrial plants, utility objects) The design of **ITEK-x20** meets the requirements of *RD-50-213-80, PR34-70-010-85, GOST 6651-84* and 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 3 check-points, a commercial metering of gas consumption in 2 check-points, that of hot water - in 3 check-points, and that of drinking water consumption - in 1 check-point

Technical metering of electric power consumption will be provided in ***40*** points, technical metering of hot water consumption - in ***6*** points, that of compressed air – in ***4*** points, that of gas – in ***4*** points

Calculation of the yearly energy saving

Practice show that after implementation at the plant of an independent automatical system for metering energy consumption and after introduction at the plant 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 ***70,100*** m^3, that of electric power – ***386,200*** kW h, that of water - ***8,000*** m^3

Calculation of the yearly energy saving

Currently, the plant pays for the energy resources USD ***670,000*** Therefore, energy saving in the pecuniary form will be

$$S_{costs} = 670{,}000 \quad 0\ 05 = \text{USD } 33{,}500$$

Commissioning costs

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

Commercial metering of consumption of electric power, gas, hot and drinking water USD***20,000***

Technical metering of consumption of electric power, hot water, compressed air, gas USD ***30,000***

Construction and commissioning works USD ***15,000***

The total costs that can be expected C_{total} = USD ***65,000***

Estimation of the simple payback period

Yearly saving of the costs - S_{costs} = USD ***33,500*** per year

Commissioning costs - $Commis_{costs}$ = USD ***65,000***

<u>Simple payback period is</u>

$$SPP = Commis_{costs}/S_{costs} = 65{,}000/33{,}500 = 1\ 9 \text{ years}$$

ECO #9 INTRODUCTION OF INFRA-RED GAS-FIRE HHEATING SYSTEMS IN THE PRODUCTION BUILDINGS AT THE PLANT

Description of the oopportunity

Steam is no used for heating of production buildings The total number of the heated buildings is *11*, their total volume is *757,000* m³ and the total consumption of thermal energy is *12,000* Gcal It should be noted that the maximum need at the plant for heat, with taking into account the heat for the dwelling houses and canteen included into the system, is *26* to *30* Gcal/h However, the boiler-house does not provide the said amount of the needed heat, its maximum production capacity is *16* Gcal/h So, in workshops electric heating is used As it was found from analysis of the plots of electric loading at the plant for 1996-1997 that are shown in Fig A 9 1, a clearly evident winter maximum exists accounted for by addition of the load associated with starting electric heating

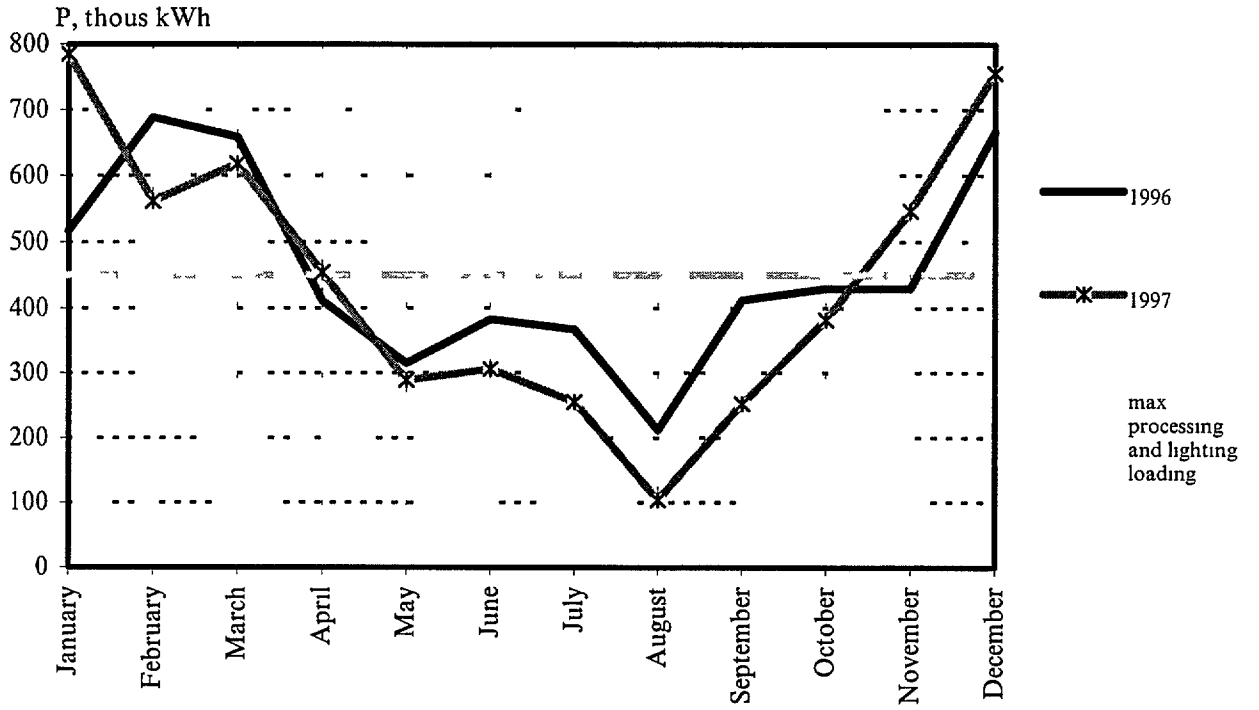


Fig A 9 1

One can see from Fig A 9 1 that in 1997 in January-March, November-December for the purposes of electric heating *1,022,000* kkW h were used and USD *44,300* were paid to the energy supplying company Though the required temperature of the air was not provided in the workshops A similar data concerning the energy efficiency are the amount of natural data is *141,000* m³ that cost USD *14,000*

It is proposed to install in Buildings #1, 2, 3 and 6 infra-red gas-fire 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

In conditions of not full loading of the production areas there is proposed to heat not the whole building, but the working places only

Calculation of the yearly energy saving

According to the data from the plant (see Appendix D) the heating needs in regard of Buildings # 1, 2, 3 and 6, with taking into account the losses in the lines and excluding the air-and-thermal gate, require the thermal energy $Q_{heaa.\ Buil.}$ = *11,686* Gcal of heat or B_1 = *1,880,000* m³ of natural gas (Table A 9 1) that is consumed by the boiler-house

The thermal energy needed for heating purposes equal to *10 4* Gcal/hour is not provided now, and currently its deficit at the plant is not compensated

It is proposed to install on the walls at the corner of *45°*, lower the crane lines, from the both sides of the bay in the locality of the working places, with taking into account the designed values of the thermal losses in the building, the following

- in the bays in Building #1 – *70* highly-efficient heaters with the total thermal capacity equal to *1,330* Mcal/h (*1,540* kW),
- in the bays in Building #2 – *60* highly efficient heaters with the total thermal capacity equal to *1,140* Mcal/h (*1,320* kW),
- in the bays in Building #3 – *40* highly efficient heaters with the total thermal capacity equal to *760* Mcal/h (*880* kW),
- in the bays in Building #6 – *40* highly efficient heaters with the total capacity equal to

  760 Mcal/h (*880* kW),

The total installed capacity of the heaters

$$N_{nom.} = 3{,}990 \text{ Mcal/h } (4{,}620 \text{ kW})$$

The maximum gas consumption per hour will be

$$B_{g2} = l \quad b_e = 210 \quad 2\ 12 = 445\ 2 \text{ m}^3\text{/h},$$

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

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

With taking into consideration the stand-by mode the gas consumption in which is *30* per cent of the consumption in the main operation mode, the gas consumption in the heating period will be

$$B_g = B_{g2} \quad [114\ (t_1 + k_3 \quad t_2) + k_3 \quad 24 \quad 51] = 445\ 2 \quad [114 \quad (8 + 0\ 3 \quad 16) + 0\ 3 \quad 24 \quad 51] = 813{,}000 = 813 \text{ thousand m}^3,$$

where $t_1, t_2, 24$ – the time of operating the heating system in the main operation mode, in the stand-by operation mode on the working days and in the stand-by operation mode on days-off, respectively, hours,

114 51 – the number of the working and non-working days in the heating period for Odesa Oblast, days,

k_3 – the coefficient of the thermal energy utilization for the heaters in the stand-by operation mode, $k_3 = 0\ 3$

The gas saving will be

$$S_{gas} = B_1 - B_g = 1880 - 813 = 1{,}067{,}000 \text{ m}^3$$

Loading of the production facilities in 1997 was *12* per cent The number of the working places in the workshops decreased correspondingly To maintain the production activities it is proposed to install in the buildings *50* infra-red heaters

Then $B'_{g2} = 50 \quad 2\ 12 = 106$ m³/h, $N'_{nom.} = 1{,}100$ kW

$$B'_g = 106\ [\ 114\ (8 + 0\ 3 \quad 16) + 0\ 3 \quad 24 \quad 51\ ] = 193{,}600 \text{ m}^3$$

Saving of natural gas in this case will be

$$S'_g = B_1 - B'_g = 1{,}880 - 193\ 6 = 1{,}686{,}400 \text{ m}^3$$

Calculation of the yearly saving on energy resources

The cost of the thermal energy required for heating the said workshops

$$WS_{ThE} = Q_{SH} \quad C_{ThE} = 11{,}686 \quad 37\ 6 = \text{UAH } 439\ 400 = \text{USD } 219{,}700,$$

where C_{ThE} – the net cost of *1* Gcal of heat, hrn

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

$$WS_{GH} = B_G \quad C_2 = 193\ 6 \quad 99 = \text{USD } 19{,}166$$

Where C_2 – the cost of *1,000* m³ of gas, USD

The yearly saving of costs $S_0 = WS_{ThH} - WS_{GH} = 219{,}700 - 19{,}166 = \text{USD } 200{,}534$

Saving of costs in comparison with the electric heating

$$S_{costs} = 44\ 3 - 19\ 16 = \text{USD } 25{,}140$$

Commissioning costs

We propose to use highly-efficient heaters infra-red heaters from the company *"Schwank"* that operate on natural gas of low pressure

The cost of the equipment

$$C_0 = l \quad C_{HEH} = 50 \quad 576 = \text{USD } 28{,}800,$$

where C_{HEH} – the price on a highly-efficient heater with taking into account the VAT, USD

The costs on commissioning (the project cost, the gas supply, the costs of the installation works) works we set equal to $C_{commis} = \text{USD } 20{,}000$

Total costs

$$C = C_0 + C_{commis.} = 28{,}800 + 20{,}000 = \text{USD } 48{,}800$$

AS it was already mentioned above, the plant lacks some thermal energy to meet its production needs, so, as an example, we can use for comparison installation of an additional boiler of the water-heating type ***KVG-7,56-150*** with the total cost of the equipment with the VAT equal to USD ***80,000*** Construction, installation and adjustment works are ≈ USD ***50,000*** All in all it is USD ***130,000*** However, in our calculation we take into account only the costs on installation of the heaters

Estimation of the simple payback period

The yearly saving of costs on energy resources – $S_0 = \text{USD } 200{,}534$

The cost on commissioning the heaters – $C_1 = \text{USD } 48{,}800$

Simple payback period

$$SPP = C/C_0 = 48{,}800/200{,}534 = 0\ 24 \text{ year},$$

or, in other words, implementation of the proposal will be paid back in ***one*** heating season

Table A 9 1

Workshop #	Production area, m^2	Volume, $m^3 \times 10^3$	Calculated room temperature, °C	Specific rate of thermal energy consumption for the heating purposes, kcal/(h m^3 °C)	Needs for the heating purposes, Gcal/year
Building #1 (17-м high)					
03	4,020	68 34	16	0 4	1,070
04	1,760	29 92	16	0 4	470
05	5,040	85 68	16	0 4	1,342
07	3,000	51 0	16	0 4	800
Total					**3,682**
Building #2 (15-m high)					
08	10,470	157 0	16	0 4	2,460
15	12,100	181 5	16	0 4	2,843
10	3,060	45 9	16	0 4	720
Total					**6,023**
Building #3(8-m high)					
Tool Workshop	1,620	12 96	16	0 45	228
Repair & Maintenance Workshop	2,010	16 0	16	0 45	282
Workshop for Consumers' Goods	1,550	12 4	16	0 45	218
Total	**5,180**				**728**
Building #6 (13 5-m high)					
Workshop for parts for the thermoplastic automates	5,930	80,0	16	0,4	1,253
Total					**1,253**
The sum					**11,686**

ECO #10 OPTIMIZATION OF THE SYSTEM OF COMPRESSOR PLANTS

Description of the opportunity

The air source for the plant if the central compressor station with air compressors Currently, as the need for production of compressed air decreased, only one compressor is in use, usually of ***VP-50/8***-type, cooling of which requires ***6*** m³/h of water The compressor station cooling system is designed on the total cooling water flow-rate of ***60*** m³/h and it consists of two loops Loop ***I*** – ***a*** service tank – a water pump of ***6K8***-type with the production capacity of the electric drive equal to ***22*** kW h, productivity of ***60*** m³/h – compressor– accumulating reservoir of ***25*** m³, Loop ***II*** accumulating reservoir – water pump of ***6K8***-type – spray-cooling pond – a service tank The pump cycle of Loop ***I*** is a continuous for ***9*** hours per day, that for the pump in Loop ***II*** switches on for work for ***15*** min to empty the accumulating tanks every ***40*** min

It is proposed to make the parameters of the pump in Loop ***I*** match the real need of the compressor station, for that the pump of ***K8/18***-type with the following parameters the maximum production capacity is $G = 15$ m³/h, the power capacity of the electric drive is $P = 1\ 5$ kW, which will allow to decrease the consumption of electric power for the purposes of cooling the compressor station with the pumps in Loops ***I*** and ***II***

Calculation of the yearly saving

It takes Pump in Loop ***I*** 40 minutes to fill the accumulation reservoir of $V = 25$ m³ Using the characteristic for the pump of ***6K8***-type we will find that the pump consumed $N_1 = 12\ 7$ kW at the productivity of $G = 34$ m³/hour

Electric power consumption by a pump of ***6K8***-type in Loop ***I***

$$W_1 = N_1 \quad t_1 \quad n = 12\ 7 \quad 9 \quad 252 = 28\ 804 \text{ kW h/year,}$$

where N_1 – the power consumed by the pump at $G = 34$ m³/hour, kW,

t_1 – the time of operating the pump per day, hour,

n – the number of the working days in a year, day

Electric power consumption by a pump of ***K8/18***-type

$$W_2 = N_2 \quad t_1 \quad n = 0\ 7 \quad 9 \quad 252 = 1{,}588 \text{ kW h/year,}$$

where N_2 – the power consumed by the pump at $G_2 = 6$ m³/hour, kW

Consumption of electric power by a pump of ***6K8***-type in Loop ***II***, if in Loop ***I*** a pump of ***6K8***-type works, is

$$W_3 = N_3 \quad t_2 \quad n = 17 \quad 2\ 5 \quad 252 = 10{,}710 \text{ kW h,}$$

where N_3 – the power, consumed by the pump at $G_3 = 100$ m³/hour, kW,

t_2 – the time of operating the pump per day, hour,

Consumption of electric power by a pump of ***6K8***-type in Loop ***II***, if in Loop ***I*** a pump of ***K/18***-type works, is

$$W_4 = N_3 \quad t_3 \quad n = 17 \quad 0\ 5 \quad 252 = 2{,}142 \text{ kW h,}$$

where t_3 – the time of operating the pump per day, hour

The total electric power saving is

$$W = 28{,}804 + 10{,}710 - 1{,}588 - 2{,}142 = 35{,}784 \text{ kW h}$$

Calculation of the yearly saving of costs

Saving of costs in the pecuniary units, if *1* kW h costs USD *0 044*

$$S_g = W \quad 0\ 044 = 35{,}784 \quad 0\ 044 = \text{USD } 1{,}575$$

Commissioning costs

The cost of the pump of *K 8/18*-type – C_1 = USD *270*

The costs of the installation works are insignificant, and they will be fulfilled by people from the plant personnel

Estimation of the simple payback period

Yearly saving of costs – S_g = USD *1,575*

Commissioning costs – $Commis_{costs}$ = USD *270*

Simple payback period

$$SPP = Commis_{costs} / S_g = 270 / 1{,}575 = 0\ 17 \text{ year (2 months)}$$

ECO #11 MONITORING AND OPTIMIZATION OF THE POWER CAPACITY OF THE ELECTRIC POWER CONSUMING PLANTS AND MACHINES

Description of the opportunity

According the data for 1997, the basic manufacture consume about *69* per cent of the total amount of the electric power consumed by the plant, which is *5,309,000* kW h per year that cost USD *233,000*

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 power on Feeder #5 supplying power into the pattering workshop and into the repair and maintenance workshop, the installed designed capacity of the motors is used on *15* to *30* per cent

At the plant there are provided *16* transformer substations of *6/0 4-kV* type, *36* compensating devices with the capacity of *7,690* kVA, induction and welding plants with electric furnaces, tanks for electric plating, etc The total capacity of the electric equipment installed at the plant is *73,300* kkW

It is proposed to introduce at the plant operation control of the power that is actually consumed by the electric equipment 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 load of motors, analyze their efficiency and organize their planned replacement with more efficient ones 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 the yearly saving

1 Yearly electric power consumption according to the data for 1997 – *7,723,000* kW h
2 *1,000* kW hcosts – USD *44*
3 Expected decreasing in electric power consumption – *1 5*%
4 Expected saving

7,723,000 kW h *0 015* = *116,000* kW h

5 Decreasing in the costs

116,000 *44* = USD *5,104*

Proposed equipment and its cost

One set of portable instruments a sort of "*2000 A Wattprobe*" or "*Power Factor Meter, TIF 2300*", with taking into account the overcast costs and the transportation costs – USD *1,000*

The costs of organizing and carrying the monitoring and analysis of the efficiency of the equipment loading (set) – USD *3,500*

The total costs – USD *4,500*

Simple payback period

USD *4,500 /* USD *5,104* = *0 9* year

ECO #12 THERMAL INSULATION OF THE HOT WATER ACCUMULATING TANK

Description of the opportunity

In the boiler-house of the plant a hot water accumulating tank is installed with the volume of $V = 22\ 8$ m^3 that performs the function of the deaerator of the stream boiler and is also used for condensate collecting, The total external area of ha tank is $F = 63\ 0$ m^2 Currently the tank is not insulated The temperature of the external surfaces of the tank varies from *60* to *80*°C There are losses of heat into the environment through the non-insulated tank walls

It is proposed to provide insulation of the tank by spraying foam polyurethane with its covering with the aluminum paint followed, which will decrease the thermal losses into the environment by *90* to *95* per cent

Calculation of the yearly energy saving

The total area where thermal insulation is absent is $F = 63\ 0$ m^2 The thermal losses into the environment is determined by means of the formula

$$Q_{cons} = L_b \quad F \quad \Delta t \quad \tau \quad 10^{-6}, \text{ Gcal},$$

where L_b – the coefficient of thermal release is

$$L_b = 8\ 4 + 0\ 06\ (t_{surf} - t_{amb\ aver}) = 8\ 4 + 0\ 06 \quad (70 - 18) = 11\ 52 \text{ kCal/(m}^2\text{ h °C)},$$

$F = 63\ 0$ m^2 – the area of the heat exchange,

t_{surf} - the temperature of the tank surface, $t_{surf} = 70$°C,

$t_{amb\ aver}$ – the average ambient temperature for a year in the space of the accumulator, $t_{amb\ aver} = 18$°C,

τ – the operation time of the accumulating tank, hour,

$$\tau = 24 \quad n_{heat} + 3 \quad n_{non\ heat} = 24 \quad 114 + 3 \quad 140 = 3{,}156 \text{ hours},$$

where n_{heat} – the number of the working days in the heating period, $n_{heat} = 114$ days,

$n_{non\ heat}$ – the number of the working days in the non-heating period, $n_{non\ heat} = 140$ days

$$Q_{cons} = 11\ 52 \quad 63 \quad (70 - 18) \quad 3{,}156 \quad 10^{-6} = 119\ 1 \text{ Gcal}$$

The specific consumption of gas in the boiler-house is $b = 162$ m^3/Gcal

The gas saving will be

$$S_g = Q_{cons.} \quad b = 119\ 1 \quad 162 = 19{,}290 \text{ m}^3\text{/year}$$

Calculation of the yearly saving of costs

Saving of the costs on natural gas, if *1* m^3 of gas costs *0* 099

$$19{,}290 \quad 0\ 099 = \text{USD } 1{,}910 \text{ per year}$$

Commissioning costs

The cost of the insulation for *63 0* m^2 of the tank surface, if *1* m^2 of the insulation costs USD *10* and the deposition method is to be used – *63 10* = USD *630 0*

The overhead costs (set as *20*%) – USD *126 0*

Total – USD *756 0*

Estimation of the simple payback period

Yearly saving - USD *1,910*

Commissioning costs - USD *756 0*

Simple payback period

756 0 / 1,910 = 0 4 year

APPENDIX B PRELIMINARY SPECIFICATIONS

Table B 1

Specifications for the equipment to be supplied to OJSC "Presmash"

Measure (due to Section 7)	Equipment	Type model	Manufacturer, country	Basic parameters	Quantity required		Price		Delivery cost		Notes
					Unit	Quantity	UAH	USD	UAH	USD	
1	2	3	4	5	6	7	8	9	10	11	12
ECO #1	Non-contact infra red pyrometer	Model *PM3L3SZ*	Company *Raytek* USA	*t = -20 + + 1000* °C *Lизм = 10* м	unit	1	–	1 600	–	1 600	
	Power analyzer	Model *DRANETZ*	Company "*Dranetz Technologies Inc* USA		unit	1	–	5,000		5 000	
	Portable anemometer	Model *444HT*	Company '*Kurz Instruments, Inc* USA		unit	1	–	1,300	–	1,300	
	Tester	Model *87*	Company *Fluke Mig Co Inc* USA		unit	1	–	500	–	500	
	Power factor meter	Model TIF 2300	Company *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*	Company *TIF Instruments, Inc* 9101 N W 7th Avenue Post Office Box 1338 Miami Florida 33238-9990		unit	1	–	600	–	600	
ECO #2	Combustion analyzer	*ENERAC - 2000*	*Energy Efficiency Systems, Inc* , 1300 Shames Drive Westbury NX 11590 USA	Gases whose content is to be analyzed O_2 CO_2 SO_2 NO_x	unit	1	–	5,000	–	5 000	
ECO #3	Water-heating boiler	*KV-0,1 GN*	JSC Ukrkotposervis' Donetsk City, Ukraine		unit	1	4,940	2 500	4 940	2 500	
ECO #4	Thermal insulating materials for steam pipelines	Glass fiber with the casing of aluminum	USA	*t = 150* °C	m	122	19 5	10 5	2 380	1 280	
	Thermal insulating materials for the hot water supply pipelines	Foampolyuritan	OJSC *Vasylkiv Plant for Refigerators* , Vasylkiv Town Kyiv Region 72 Soborna Str , Ukrainея 72 Украина	*t = 100* °C	m	112	15 9	8	1 780	900	

Table B 1 (cont)

1	2	3	4	5	6	7	8	9	10	11	12
ECO #5	System for automatic controlling condensate plants	***UKM 62-0,4***		***U = 0 4*** kV						8 000	
ECO #6	Sodium high pressure lamp with the starting up device	DNaT 250 3 DNaT-100 3	OJSC Poltava Gas-Discharging Lamps Plant 3 Zavodska Str Poltava Ukraine,	***U = 220*** V ***P = 250*** W ***P = 250*** W	unit unit	55 95	– –	35 0 30 0	– –	1 925 2 850	
ECO #7	Combustion analyzer	***ENERAC - 2000***	***Energy Efficiency Systems, Inc*** 1300 Shames Drive Westbury NY 11590 США	Gases the content of which should be analyzed ***O_2 CO_2 SO_2 NO_x***	unit	1	–	5 000	–	5 000	
ECO #8	A set of technical instruments for metering and checking energy consumption	***ITEK*** (with USA components)	R&P Institute Enerhiya+ 37 Peremoha Prospekt Building 22, Kyiv Ukraine 252056	Commercial and technical metering	set set	1 1		20,000 30,000		20,000 30,000	
ECO #9	Infra-red gas-fire highly efficient heaters	***JR - 50***		***P = 22*** kW	unit	50		576		46 440	
ECO #10	Cold water pump	***K8/18***		***G = 15*** m³/h ***P = 1 5*** kW ***U = 380*** V	unit	1		270		270	

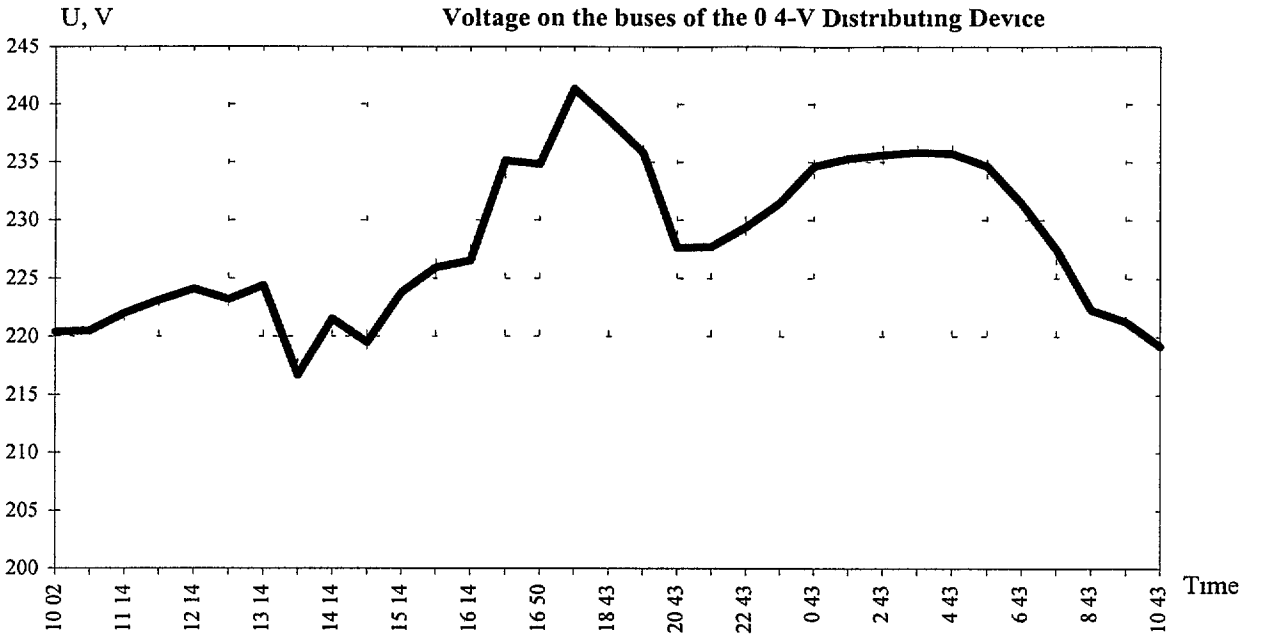
APPENDIX C MEASURED AND COLLECTED DATA

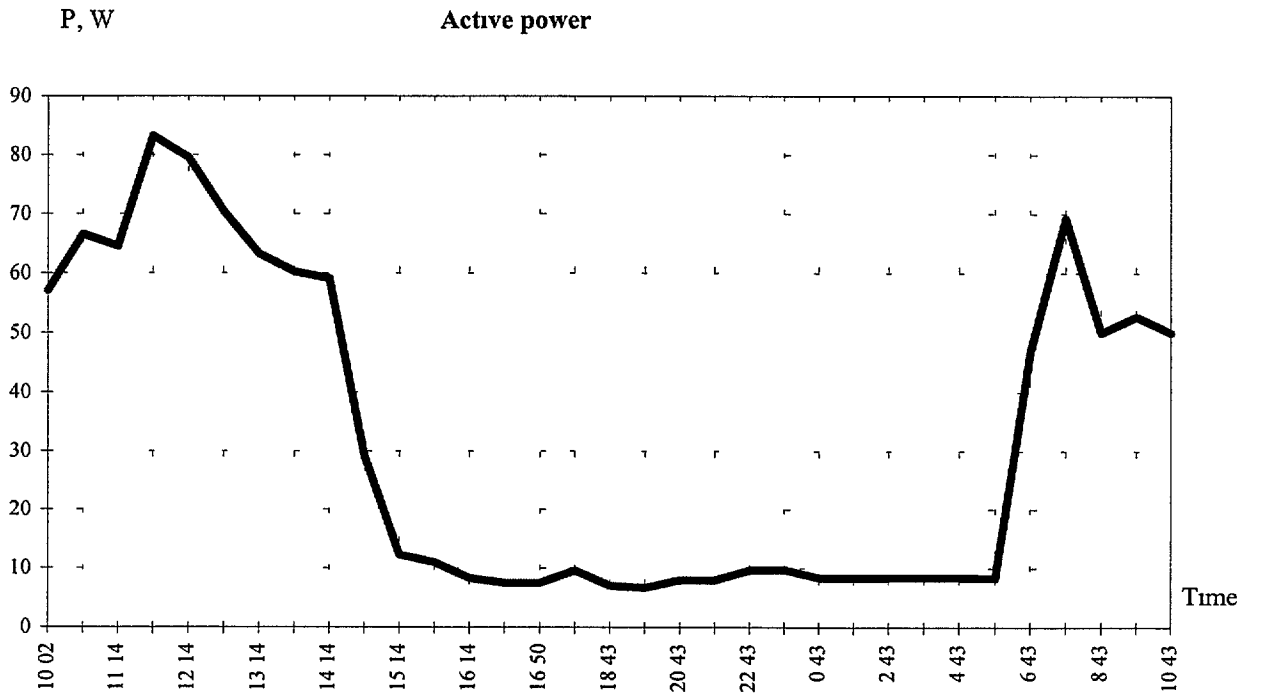
The results of measurements of parameters of gas combustion in the two-chamber drying furnace by means of "***BACHARACH***" analyzer

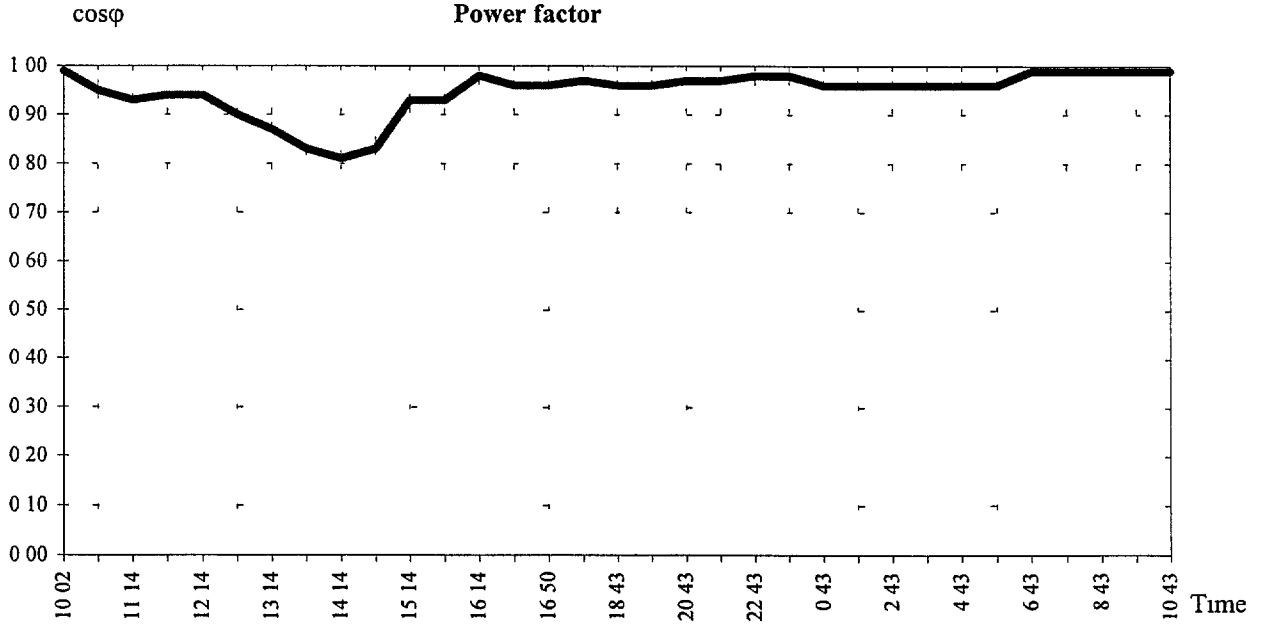
Place of measurement		
In the center of the furnace at 2/3s of the height	In the center of the furnace under the ceiling	In the center of the furnace under the ceiling
BACHARACH MODEL CA300NSX	BACHARACH MODEL CA300NSX	BACHARACH MODEL CA300NSX
**********	**********	**********
COMBUSTION ANALYZER	COMBUSTION ANALYZER	COMBUSTION ANALYZER
ID _____	ID _____	ID _____
SER NO VCO 512	SER NO VCO 512	SER NO VCO 512
TIME 21 45	TIME 21 50	TIME 21 52
DATE 14, 04, 98	DATE 14, 04, 98	DATE 14, 04, 98
FUEL NATURAL GAS	FUEL NATURAL GAS	FUEL NATURAL GAS
PRIMRY TEMP <C> 21	PRIMRY TEMP <C> 21	PRIMRY TEMP <C> 21
STACK TEMP <C> 271	STACK TEMP <C> 324	STACK TEMP <C> 314
% OXYGEN 15,0	% OXYGEN 14,4	% OXYGEN 14,3
% EXCESS AIR 232	% EXCESS AIR 202	% EXCESS AIR 198
% CARBON - DIOXIDE 3,3	% CARBON - DIOXIDE 3,6	% CARBON - DIOXIDE 3,7
PPM CARBON - MONOXIDE 23	PPM CARBON - MONOXIDE 39	PPM CARBON - MONOXIDE 55
PPM MOX 29	PPM MOX 30	PPM MOX 31
PPM SULFUR - DIOXIDE 0	PPM SULFUR - DIOXIDE 0	PPM SULFUR - DIOXIDE 0
% EFFICIENCY 70,2*	% EFFICIENCY 66,9*	% EFFICIENCY 68,3*
% STACK LOSS 29,8*	% STACK LOSS 33,1*	% STACK LOSS 31,7*
TEST PERFORMED BY	TEST PERFORMED BY	TEST PERFORMED BY

The results of measurements of the parameters of gas combustion in the boiler of ***DE-6,5-13*** by means of ***"BACHARACH"*** combustion analyzer, the steam pressure was *5* kg/cm^3

Place of measurement		
After the economizer	Before the economizer	Before the economizer
BACHARACH MODEL CA300NSX **********	BACHARACH MODEL CA300NSX **********	BACHARACH MODEL CA300NSX **********
COMBUSTION ANALYZER	COMBUSTION ANALYZER	COMBUSTION ANALYZER
ID _____	ID _____	ID _____
SER NO VCO 512	SER NO VCO 512	SER NO VCO 512
TIME 15 25	TIME 15 40	TIME 15 44
DATE 14, 04, 98	DATE 14, 04, 98	DATE 14, 04, 98
FUEL NATURAL GAS	FUEL NATURAL GAS	FUEL NATURAL GAS
PRIMRY TEMP <C> 25	PRIMRY TEMP <C> 27	PRIMRY TEMP <C> 27
STACK TEMP <C> 69	STACK TEMP <C> 218	STACK TEMP <C> 215
% OXYGEN 19 7	% OXYGEN 16,3	% OXYGEN 16 7
% EXCESS AIR 499	% EXCESS AIR 323	% EXCESS AIR 362
% CARBON - DIOXIDE 0,7	% CARBON - DIOXIDE 2,6	% CARBON - DIOXIDE 2,4
PPM CARBON - MONOXIDE 379	PPM CARBON - MONOXIDE 1474	PPM CARBON - MONOXIDE 1420
PPM MOX 0	PPM MOX 1	PPM MOX 1
PPM SULFUR - DIOXIDE 7	PPM SULFUR - DIOXIDE 27	PPM SULFUR DIOXIDE 32
% EFFICIENCY 77,3	% EFFICIENCY 71,5	% EFFICIENCY 69,5
% STACK LOSS 22,7*	% STACK LOSS 28,5*	% STACK LOSS 30,5
TEST PERFORMED BY	TEST PERFORMED BY	TEST PERFORMED BY



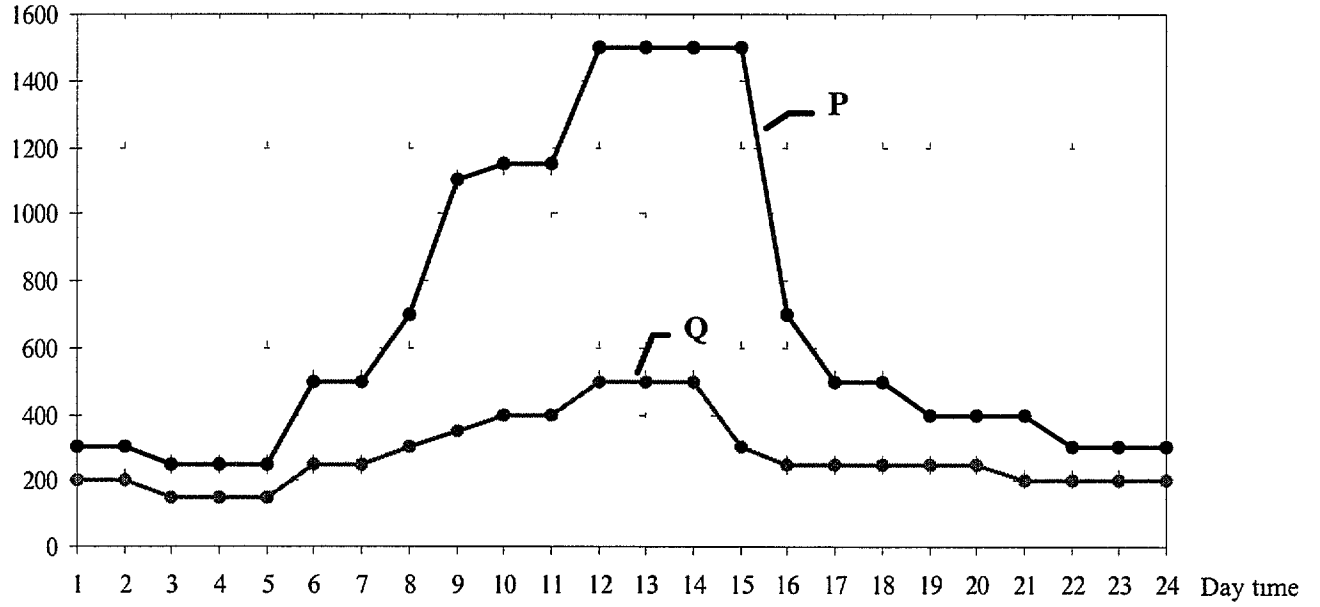




Results of measurements of parameters for the plots of the electric loading for the group of drums in the tanning workshop on 25 03 98 г

Results of measurements of electric loading on June 25, 1997

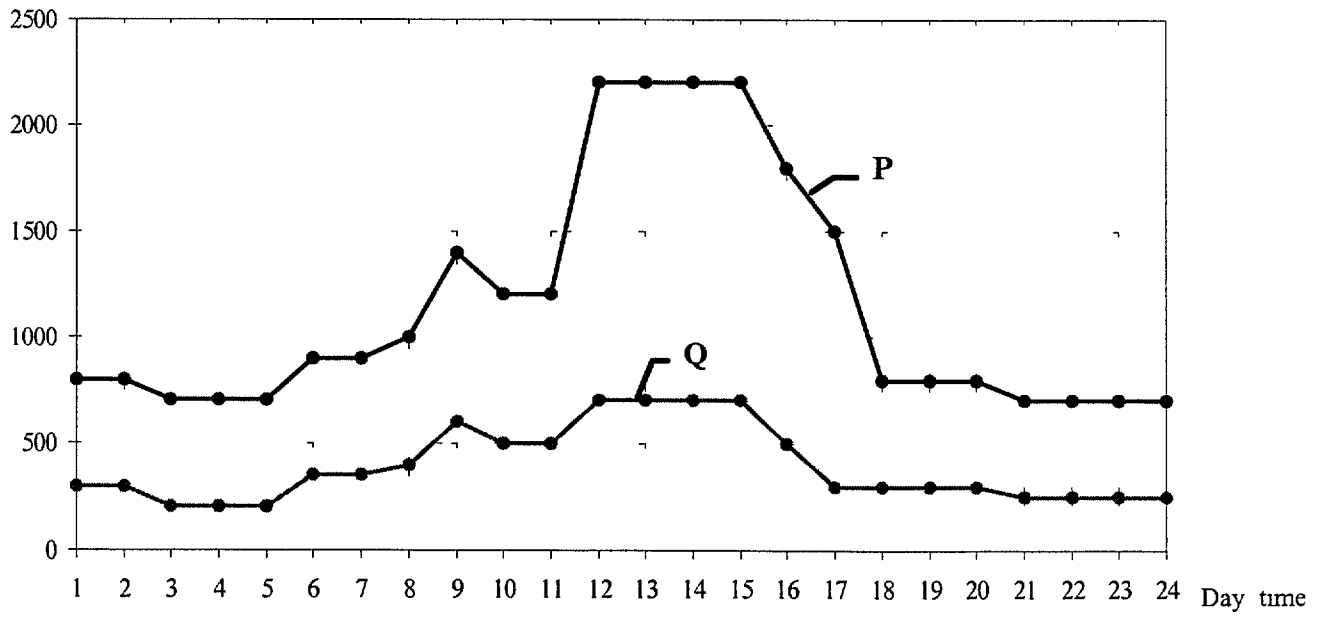
Day time	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
P kW	300	300	250	250	250	500	500	700	1100	1150	1150	1500	1500	1500	1500	700	500	500	400	400	400	300	300	300
Q kVA	200	200	150	150	150	250	250	300	350	400	400	500	500	500	300	250	250	250	250	250	200	200	200	200



The plot for loading at OJSC "Presmash" on June 26, 1997 (the installed capacity is ***15,500*** kW, the maximum loads at the peak moments are as follows ***1,500*** kW, A_{day} = ***16,250*** kW h, ***Q = 7,150*** kVA, ***cosφ = 0 4***)

Results of mesurements of electric loading on December 17, 1997

Day time	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
P kW	800	800	700	700	700	900	900	1000	1400	1200	1200	2200	2200	2200	2200	1800	1500	800	800	800	700	700	700	700
Q kVA	300	300	200	200	200	350	350	400	600	500	500	700	700	700	700	500	300	300	300	300	250	250	250	250



The plot for the loading at JSC "Presmash" on 17 12 97 (the installed capacity is ***15,500*** kW, the maximum loads at the peak moments are as follows ***2,200*** kW, A_{day} = ***28,900*** kkW h, ***Q = 9,400*** kVA, ***cosφ = 0 31***)

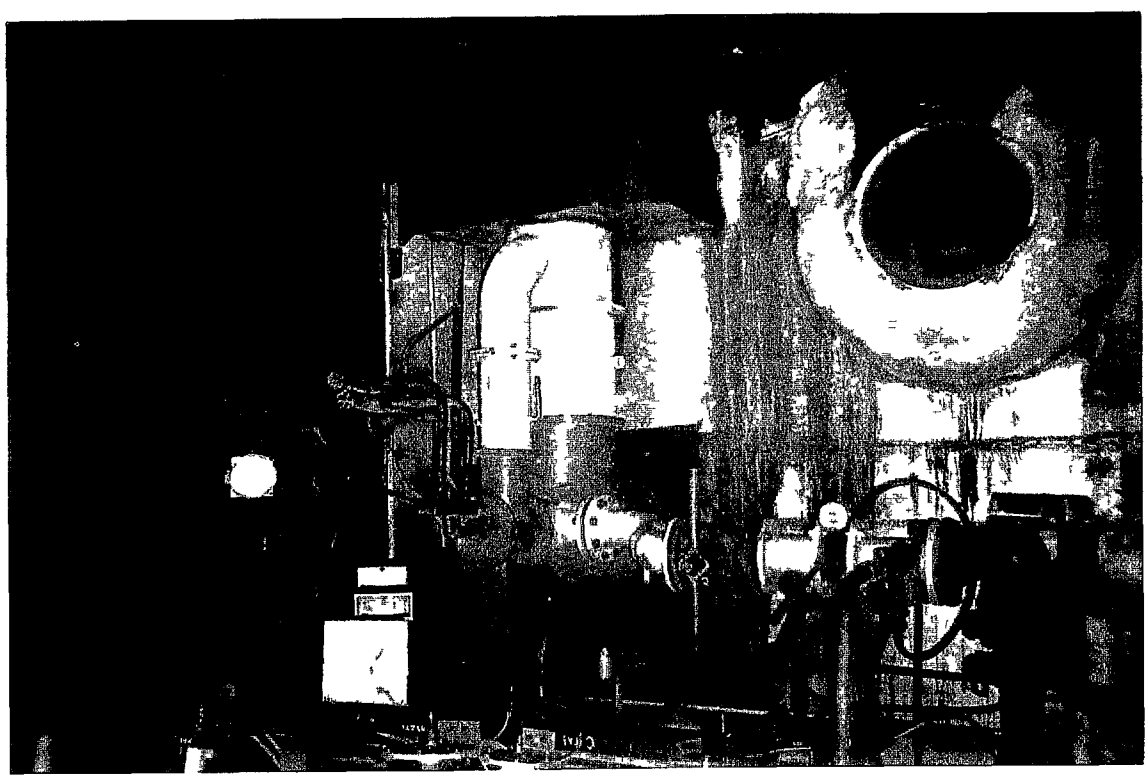
Summed up figures of electric power utilization at OJSC "Presmash" in 1997

Sort of energy	Measure unit	Months in 1997											
		01	02	03	04	05	06	07	08	09	10	11	12
Active	*kW h x 10³*	785 84	561 9	617 87	453 7	289 46	305 81	254 66	103 83	251 5	381 73	547 11	755 95
Reactive	*kVAr x 10³*	538 5	653 3	513 8	375 1	326 8	310 0	275 9	86 8	288 4	372 1	322 7	6 1
Power factor	–	0 825	0 652	0 769	0 771	0 663	0 702	0 678	0 767	0 657	0 716	0 861	0 999

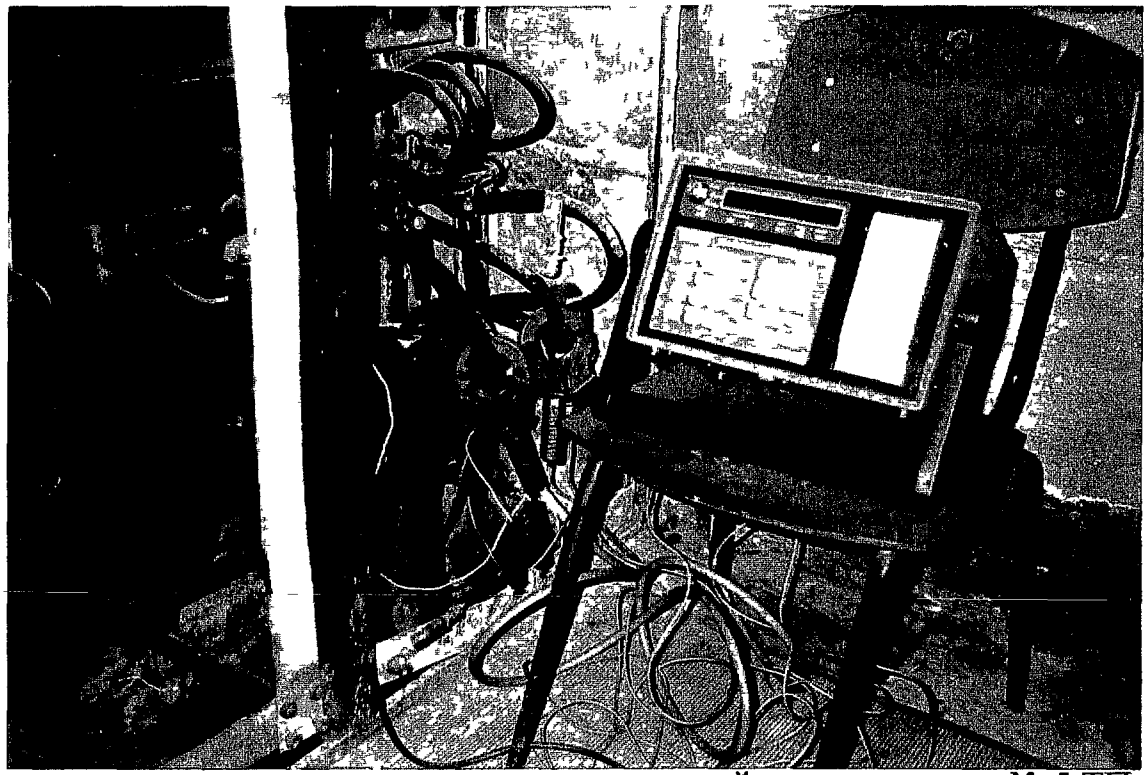
APPENDIX D PHOTOGRAPHS OF THE PLANT

12

Корпус конструнторского бюро “Прессмаш”
Building of her Designing Bureau at “Presmash”

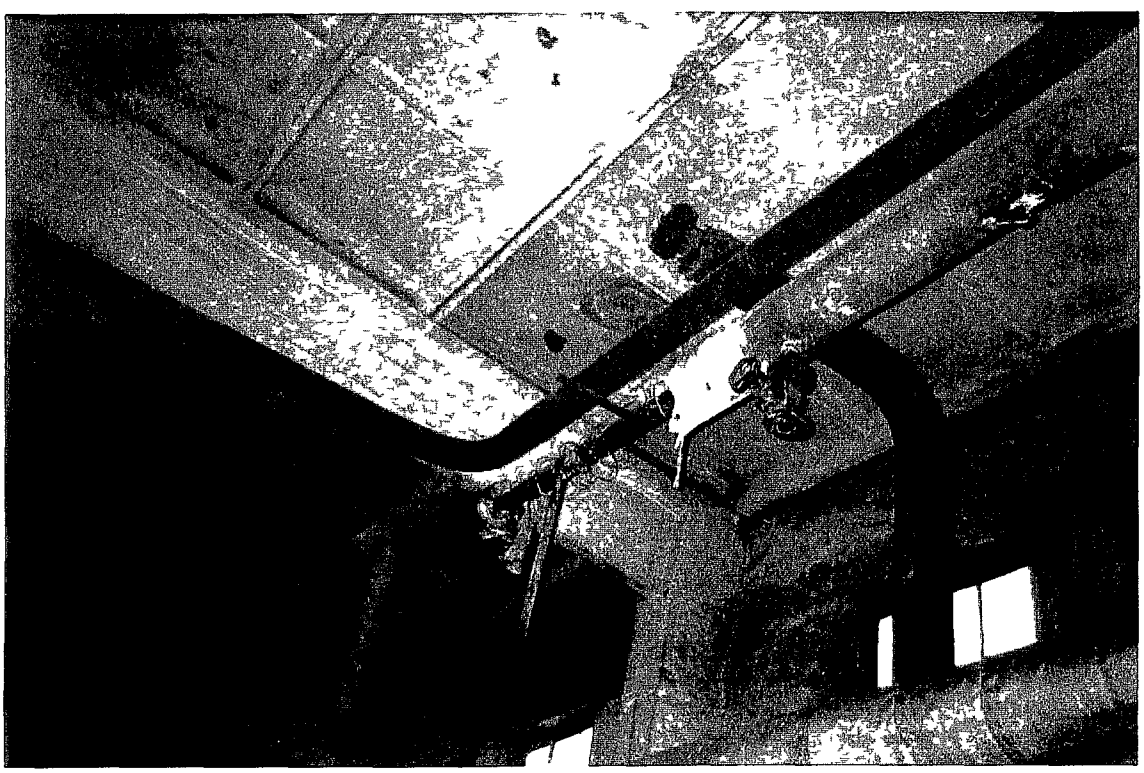


Горелка ГМГ - 5м, установленная на котле ДЕ - 6,5/13
GMG- 5m Burner installed on *DE- 6,5/13* Boiler



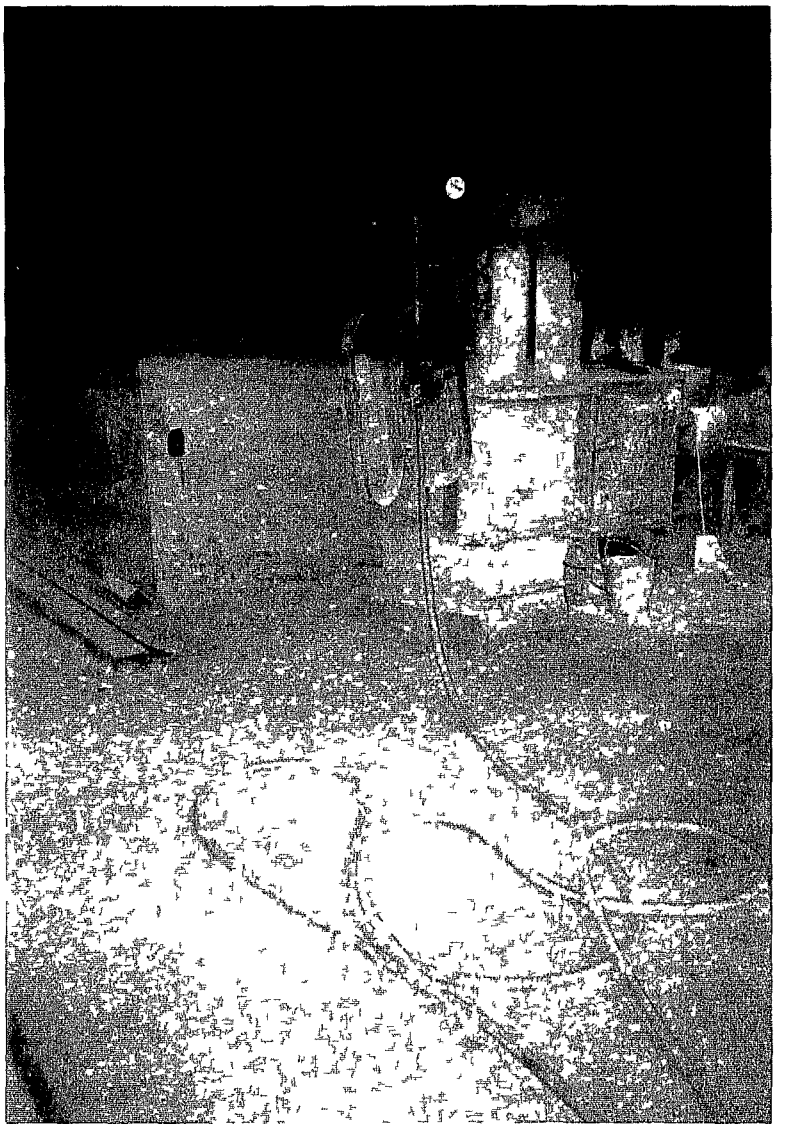
Измерение электрических параметров отходящей линии корпуса № 5 ТП-8 с помощью прибора DRANETZ

Measurement of electric parameters of the output line *TP-8* in Building #5 by means of *DRANETZ* meter



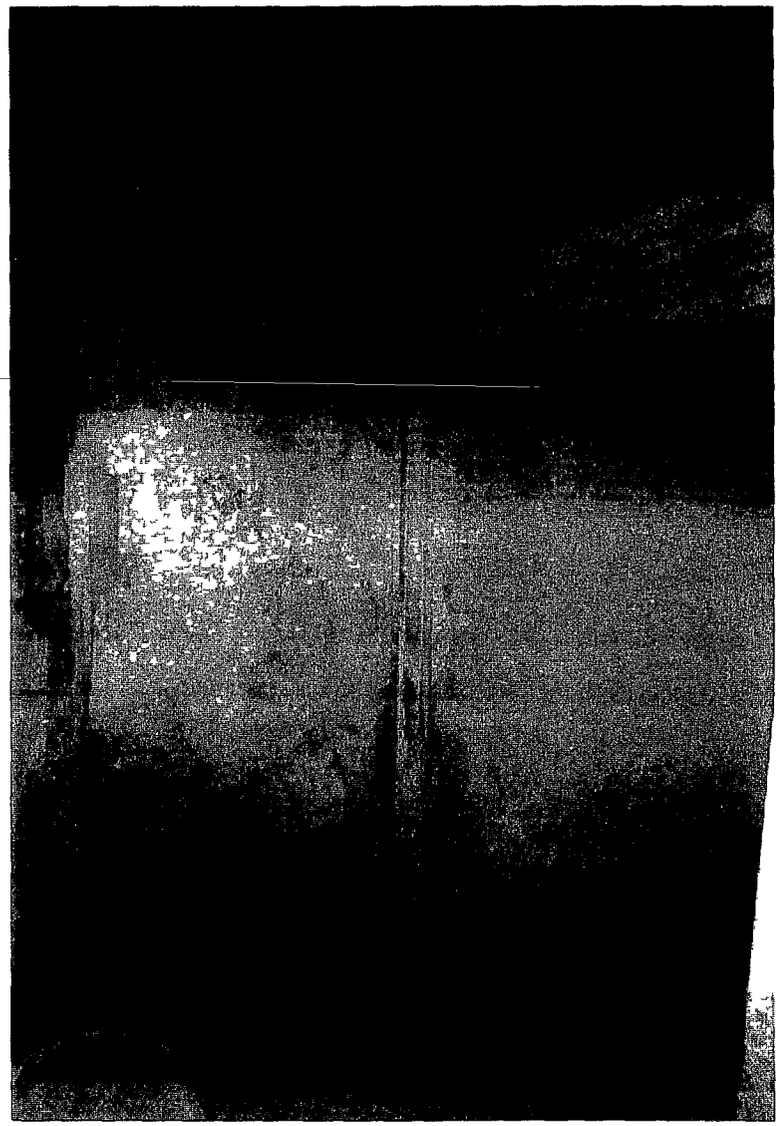
Состояние термоизоляции

Thermal insulation state



Использование газа для предварительной сушки форм
Use of gas for the preliminary drying of moulds

Состояние тепловых завесов ворот производственного корпуса
State of the thermal gate in the production workshop



Состояние ворот сушильной камеры
State of the drying chamber gate

Состояние бойлера и конденсатоотводных узлов в котельной
State of the boiler and condensate trapping assembles in the boiler-house

APPENDIX E CONVERSION FACTORS

Currency rates of exchange

1 hrivnia - local currency unit
1hrivnia = US$0 54 as of December 1997

Conversion factors

Heat

1 cal = 4 187 J
1 kcal = 4 187 kJ = 3 968 BTU
1 Gcal = 4 187 x 10^3 = 4 187 GJ
1 BTU = 1055 J = 1 055 kJ = 1 055 x 10^3 MJ
1 tce (tonne of coal equivalent) = 7,000 kcal x 3 968 BTU = 27,78 x 10^6 BTU = 27,78 MBTU

Power

1 W = 3 6 x 10^3 J = 3 6 kJ
1 kW = 3 6 x 10^3 kJ = 3 6 MJ = 860 Kcal
1 MW = 3 6 x 10^3 MJ = 860 Kcal
1 kcal = 1 163 x 10^3
1 Gcal = 1163 kW = 1 163 MW
1 kW = 1 36 HP
1 kW = 1 34 hp

Pressure

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

Length

1 mm =0 03937 in = 0 00328 ft
1 cm = 0 3937 in = 0 0328 ft
1 m = 3 937 in = 3 281 ft

Weight

1 gram = 2 2046 x 10^3 lb
1 kg = 2,2046 lb
1 t = 1000kg = 2 2046 x 10^3 ft

Area

1 cm^2 = 0 155 square in = 1 076 x 10^3 square ft
1 m^2 = 1 55 x 10^3 square in = 10 76 square ft

Volume

1 m^3 = 35 31 cu ft = 1000 l
1l = 35 31 x 10^3 cu ft
1l = 0 264 US gal

Heat content

1 kJ/kg = 0 43 BTU/lb
1 kJ/m^3 = 26 84 x 10^3 BTU/cu ft
1 MJ/m^3 = 26 84 BTU/cu ft
1 kcal/m^3 = 4,187 kJ/m^3 = 0 112 BTU/cu ft

Temperature

^{0}C = 0 56 (^{0}F-32)

APPENDIX F ABBREVIATIONS

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 Celcium
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