PN-ACD-559
99376

Delivery order #30
Energy Efficiency in the industry of Ukraine
March 1998

REPORT

ON ENERGY AUDIT

AT CLOSED-TYPE JOINT-STOCK COMPANY

"VOZKO"

Town of Voznesensk, Nikolayev Region, UKRAINE

Prepared by Victor Svistunov
Vladimir Prokopenko

Prepared for United States Agency for International Development
Washington, DC 200523-1415

Burns and Roe Enterprises, Inc
1400 K Street, N W , Suite 1050, Washington, DC 200005
Telephone 202-408-6831 Facsimile 202-408-6835

1

Table of Contents

PREFACE 3

1 0 EXECUTIVE SUMMARY 4

1 1 INTRODUCTION 4
1 2 BRIEF SURVEY 4
1 3 RECOMMENDATIONS 5
1 4 OPERATION AND ENERGY MANAGEMENT 8
1 5 IMPLEMENTATION 9

2 0 GENERAL BACKGROUND 10

2 1 THE ENTERPRISE HISTORY 10
2 2 RECENT PRODUCTION 11
2 3 SIGNIFICANCE OF THIS SECTOR FOR THE NATIONAL ECONOMY 13

3 0 CURRENT STATUS OF PRODUCTION 14

3 1 TOTAL CAPACITY OF PLANT 14
3 2 RECENT PRODUCTION 1997 VS 1995 AND 1996 14
3 3 PROSPECTS OF DEVELOPMENT 14
3 4 EXPORTS VS DOMESTIC SALES 15

4 0 FINANCIAL STATUS 16

4 1 CURRENCY VS BARTER 16
4 2 VIABILITY OF THE PLANT 16

5 0 ANNUAL ENERGY CONSUMPTION AND COSTS 17

5 1 ANNUAL CONSUMPTION 1995, 1996 & 1997 17
5 2 CURRENT TARIFFS FOR FUEL AND ENERGY 21
5 3 ENERGY USE PROFILE 21

6 0 PREVIOUS ENERGY IMPROVEMENTS 29

7 0 ENERGY AUDIT 30

8 0 ENVIRONMENTAL IMPACTS OF RECOMMENDATIONS 37

APPENDIX A ENERGY CONSERVATION OPPORTUNITIES (ECO) 39

APPENDIX B SPECIFICATIONS FOR THE REQUIRED EQUIPMENT 67

APPENDIX C COLLECTED AND MEASURED DATA 71

APPENDIX D PHOTOGRAPHS OF THE PLANT 77

APPENDIX E ABBREVIATIONS AND MEASUREMENT UNITS 78

PREFACE

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 of ***USAID***

Each facility was evaluated based on selection criteria (approved by USAID) for the selection of target plants The criteria included a long-term economic viability of the plant, its financial condition, its generation of export revenues, production output versus nominal capacity, energy conservation potential, possibilities of project replication at similar enterprises and its access as a demonstration facility to other plants

This report details the findings of ***BURNS & ROE ENTERPRISES, Inc*** energy report performed at the AT CLOSED-TYPE JOINT-STOCK COMPANY "VOZKO", town of Voznesensk, Nikolayev region

1 0 EXECUTIVE SUMMARY

1 1 Introduction

The closed-type joint stock company "Voznesensk leather amalgamation" (CJSC VOZKO) is a modern dynamically growing enterprise and one of the largest in its sector in Ukraine

Continuous renovation of products and search for new technologies allow the plant to increase production annually and consistently produce the output of guaranteed quality

This energy audit has been conducted under a program sponsored by the US 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 primary 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

The team consisting of two representatives of US firm ***Burns and Roe*** who are experts in the field of energy management - Victor Svistunov and Vladimir Prokopenko - carried out an energy audit from March 23 through 27 1998 in accordance with the tasks of the project and prepared the report

Since these industries are very large, a one week site visit is not sufficient to adequately audit the entire facility The site visit was restricted to one week due to other project considerations However, the engineering staff were trained to identify improvements that would be representative of the entire plant In many cases it was necessary to focus the auditing efforts on one system or only on a portion of the plant Therefore, this audit is based on what could be accomplished during the one week allocated While this audit contains numerous recommendations for the plant management, the plant management is encouraged to perform a complete audit of the entire facility Hopefully, the plant management will consider hiring the engineers trained under this project to continue this work, which will result in a complete understanding of energy usage within the plant, as well as a complete listing of all potential, energy improvement projects

1 2 Brief survey

- The CJSC VOZKO by Ukrainian standards is a stably functioning enterprise
- Out of total cost for energy resources heat makes up approximately *73%* Over *75%* of electric power consumption goes for main production lines (liming, tanning, staining, finishing) and at the boiler house and compressor unit These consumption facilities define primary sources of energy conservation In the total production costs energy expenses amount to *7 5%*

- As expected the energy audit team has discovered many attractive opportunities of improving energy efficiency at the current energy and fuel prices When energy prices were ***20 to 30*** times lower the energy improvement measures were not cost efficient Presently the energy efficiency improvement is cost effective though difficult to implement due to high interest rate of the bank credit and general economic challenges due to the bartering settlement system and mutual non-payments
- Lack of technical submetering denies organization of an objective base for energy conservation and institute a full-scale energy management system
- An important area for energy conservation is the improvement of steam use efficiency by introduction of steam traps, enhancement of thermal insulation of steam- and condensate piping, and increase of condensate recovery
- Reduction of electric power use can be achieved by improving the efficiency of refrigeration and compressed air generation and consumption systems, and by introduction of energy efficient lighting sources

1 3 Recommendations

The following table 1 1 is a summary of energy conservation opportunities identified for the facility, the estimated savings as well as the cost savings and the paybacks for each opportunity For example, ECO #1 "Energy management institution" will set up systematic energy conservation activities by establishment of an energy management section responsible for the control and analysis of the energy consumption at the plant and development of recommendations for renovation and improvement of any energy saving systems

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

ECO #3 "Installation of steam trap units" will reduce steam use without deterioration of thermal characteristics of the equipment with simultaneous improvement of its efficient use at the local waste water treatment facilities, in the space heating and ventilation systems, and the hide shreds boiling unit

ECO #4 "Thermal insulation of steam- and hot-water piping" will cut down direct losses of thermal energy

ECO #5 will optimize combustion of natural gas in boilers utilizing portable combustion analyzer, improve combustion efficiency and, consequently, reduce consumption

ECO #6 due to installation of 82 efficient lighting sources instead of DRL-250 lamps and conventional lamps for the external lighting will increase reliability and reduce total use of electricity,

ECO #7 will change the pressure reduction mode at the boiler house instead of a reduction unit it is proposed to install two steam electric generators that will utilize wasted steam reduction energy for electricity generation

ECO #8 will change the space heating system of the entire building to workplace heating with efficient direct gas combustion infra-red heaters that will reduce gas consumption by 50%

The list of energy conservation opportunities

Table 1 1

#	Description	Electricity, 1,000 kWh	Natural gas savings, 1,000 m^3	Annual savings, US$ (1997 prices)	ECO cost, US$ (1997 prices)	Payback, years
1	Organization of energy management system	1,220	405 3	92,200	85,000	0 92
2	Reactive power compensation in the enterprise electricity supply system	1,000		30,020	100,000	3 3
3	Installation of steam traps in steam consuming systems		197 0	41,905	9,336	0 24
4	Steam and hot water-piping insulation		224 3	23,858	4,869	0 2
5	Improvement of combustion efficiency in DKVR4-13 boilers		477 8	39,660	6,500	0 16
6	Energy efficient lighting	57 8		2,773	2,460	0 9
7	Utilization of steam reduction energy for electric power generation	2,500		120,000	125,000	1 0
8	Infrared heating with direct combustion of natural gas		1,650	205,730	190,200	0 92
9	Automatic energy metering	1000	405	85,000	150,000	1 8
10	Introduction of air curtain blocking while opening gates of the main building	150 9	502	60,647	5,000	0 08
11	Replacement of single-pane windows with double-pane		15 4	1,643	6,500	4 0
12	Monitoring of boiler equipment operation and temperature modes of heat-consuming equipment		41 9	4,560	1,000	0 22
13	Monitoring of electric motor capacities and electric power use	319		15,312	6,500	0 43
	Total	**6,247 7**	**3,918 7**	**638,308**	**542,965**	

ECO #10 will exclude operation of air curtain systems while the gates are closed resulting in energy savings

ECO #12, 13 by introduction of instrumental metering of insulation state, temperature of energy carrier and optimal use of electric equipment capacities will exclude non-rational modes of its operation and reduce energy consumption

Capital investment to the amount of US286,465 into energy efficiency improvement with short-term payback will lead to annual savings of US$520,650, and reduction of electric power use by 4,247 1 thousand kWh and natural gas use by 3,498 3 thousand cubic meters Investment of US$256,500 into energy efficiency with payback periods of more than 1 year will lead to annual savings of US$116,643 and will cut down electric power use by 2,000 thousand kWh and natural gas use by 420 4 thousand cubic meters These are the following ECO #2 "Improvement of reactive power compensation" will change $tg\phi_1 = 0\ 8149$ to $tg\phi_2 = 0\ 23$ and save 1,000,000 kWh per year, ECO #9 "Automatic energy metering" will lead to an objective picture of energy use, will encourage energy conservation activities, specify energy use by production units for in-plant settlements, ECO #11 will replace 600 m^2 of single window panes with double ones and reduce energy use for space heating Payback periods of ECO # 2, 9, 11 is less than the service life of implemented proposals

Total reduction in electric power use will be at 6,247 7 thousand kWh (25 4 % of the 1997 use), in natural gas at 3,918 7 thousand cubic meters (48 3%)

Total reduction of pollutant emission resulting from recommended ECOs will be 108 75 tons, including 27 5 tons of solid particles, 3 56 tons of carbon monoxide, 15 83 tons of nitrogen oxides, 61 86 tons of sulphur oxides

The ECOs above can be implemented at various industrial enterprises i e serving as standard solutions of common 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 output Therefore it is sometimes difficult to think of the importance of energy and energy costs on the operation of the plant

For the CJSC VOZKO as with most industries in Ukraine previously energy costs made up an insignificant share of total production costs, hence the energy was not a major consideration in plant operations

With the rising energy costs over the past few years, energy costs have now become very significant For, the CJSC VOZKO energy costs are now about *7 5* percent of the cost of production in 1997

While energy and energy costs are now well understood by the staff, there is the tendency at the CJSC VOZKO to think mainly of having to implement large projects with the intent of saving large amounts of energy This is unfortunate since many small energy saving projects exist that have very good payback periods

But it is common to ignore these since the savings per unit might be low For instance, the installation of steam traps might not seem as attractive as installing a large project

such as ammonia compressor room modification But these small projects are very important, and when the total number of steam traps is considered, the total savings resulting from this item is very significant

Most industries in Ukraine have a person or persons who are referred to as energy engineers These specialists are responsible for uninterrupted energy supply of necessary quality and amounts to production lines, and ensuring energy savings However, due to cuts in production costs typically the specialists of auxiliary services are the first to be laid off, energy supply service included This results in remaining specialists mostly tackling not the energy efficiency issues at their plants but ensuring that there is adequate supply of energy 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 routinely be 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, identify causes of them and make decisions on the necessary energy consumption remedial measures to prevent unreasonable energy use 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, certification of technologies and equipment for energy efficiency 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 It would be good to have a thermal specialist (someone who is knowledgeable about steam, refrigeration, hot water, and natural goes systems) and an electrical specialist

In 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 ECOs listed in Table 1 1 is planned following completion of the project

2 0 GENERAL BACKGROUND

Name - Closed-type joint-stock company VOZKO

Managing director - Sergey Moiseyevich Kerner

Chief engineer - Valentin Yevseyevich Burmistr

Phone No (05134) - 43-4-98

Fax No (05134) - 50-00-43

Mail address UKRAINE 329600 Nikolayev region, Voznesensk, Oktober revolution street, 287

2 1 The enterprise history

The CJSC VOZKO was commissioned in 1978 The primary activity is manufacturing of chrome leather for footwear top Capacity of enterprise is 380 mln square decimeters of chrome leather and 96 mln square decimeters of split leather per year The tannery processes raw cattle hides weighing 20-30 kg Daily nominal soaking capacity is 4 5 thousand hides In 1990 - 1992 the tannery renovated its production equipment replacing obsolete equipment In 1993 the enterprise was converted into a joint-stock company The stock capital distribution is shown in the Table 2 1

Ownership of capital and distribution of stock

Table 2 1

Name of stockholder	%
Statutory capital, including	**100 00**
• Property of the labor collective	52 0
• Property of US company Tristar	48 0

There are the following buildings and constructions within the territory of the enterprise
- office building,
- main processing building comprising the following

- liming workshop,
- tanning workshop,
- staining workshop,
- finishing workshop,
- mechanical workshop,
- electric workshop,
- chemical workshop,
- air compressor room,
- boiler house,

- water pumping station,
- wastewater treatment facilities,
- local wastewater treatment units,
- motor transport unit

Outside the main production site there are

- technical water scoop with first-stage pumps at the Yuzhny Bug river,
- treatment facilities with three sewer pumps at the 13-km sewer line

The company also includes
- hide preparation plant,
- shoe factory

2 2 Recent production

The VOZKO produces chrome leather for footwear top, leather for general wear, furniture leather, lining leather, Crust semifinished leather, tanned semifinished leather

The sequence of leather processing by production units is as follows

Hide preparation plant

- Hide trimming - removal of unneeded parts of hides at the perimeter which may cause difficulties during machine processing and lead to waste
- Separation of hide shoulders from medium- and heavy-weight cattle hides to facilitate further processing

Liming and soaking workshop

- Soaking and liming processes are liquid chemical treatment processes to soak the hides to the maximum and soften the skin structure in order to prepare the hides for tanning Alkaline treatment of hides results in removal of hair, necessary plumpness, and swollen hides are transferred for mechanical processing in the same workshop
- Mechanical operations in the liming and soaking workshop
  - scraping to remove shreds from hides,
  - splitting of hide shoulders, small-size whole hides to cut the hides in two layers for further economical processing

Cost of processing in the liming and soaking workshop is ***8 5%*** of the total production cost

Tanning workshop

- Preparatory and tanning processes are liquid chemical treatment processes to prepare swollen hides for the primary process of tanning and achieve semi-finished leather of Wet-Blue type
- Mechanical operations in the tanning workshop
  - wringing to remove excessive moisture from tanned semi-finished product to *55-65%* content,
  - splitting of unshouldered hides to cut the hides in two layers for further economical processing
  - slicking to plane even whole hides and to achieve required thickness

Cost of processing in the tanning workshop is *15 4%* of the total production cost

The grade of the semi-finished product is determined by the quality of raw material

Staining and drying workshop

- Scraped semi-finished product is chemically treated i e is stained and fat-liquored as follows
  - neutralized by alkaline treatment to prepare the semi-finished product for further staining and fat-liquoring,
  - stained by organic dyes,
  - liquored by fat emulsions to get soft elastic leather,
  - superficially tanned and stuffed consisting of treatment of the semi-finished product with various superficial tanning and stuffing substances in order to achieve required properties of leather elasticity, softness, stuffing, etc

- Mechanical operations in the staining workshop
  - wringing and flattening to smooth leather and remove excessive moisture,
  - drying and moisturizing, staking are operations for achieving standard moisture content in skins of *12-16%,* for softening and elasticity
  - drum-breaking for several types of leather to enhance softness

Cost of processing in the tanning workshop is *52 3%* of the total production cost

Finishing workshop

In the finishing workshop each type of leather is processed by its own technology

Leather with improved surface is buffed Natural looking leather is not buffed

Then skins are coated with acrylic-based polymers or with mixture of polymers and polyurethane As a rule skins are coated twice with interim pressing by smooth plate and engraved plate Coating is fixed by nitrovarnish or water varnish

Leather with double color coating of the Amigo or Sofpitta require additional processing at the Colorama

Leather with fat coating of Crazy-Horse or Pull-Up type after buffing are fat-coated and polished

Cost of processing in the finishing workshop is ***22 9%*** of the total production cost
Finished skins are sorted, measured and packed

The CJSC VOZKO according to 1997 data supplies to the internal Ukrainian market ***63***% of output, the rest goes for exportation (see subsection 3 4)

The company has 2 specialized stores, shoe factory, dress making workshop
Average number of the tannery staff is 1,000

2 3 Significance of this sector for the national economy

The plants with similar operations exist in Ukraine Total number of them is around 12

The enterprise produces 50% of leather products in Ukraine and has great importance as the source of leather for shoe and apparel industries

3 0 CURRENT STATUS OF PRODUCTION

3 1 Total capacity of plant

The design capacity of the enterprise ensures output of 386,600 thousand square decimeters of chrome leather per year

3 2 Recent production 1997 vs 1995 and 1996

In 1995-1997 the enterprise operated at reduced capacity due to the reorientation of raw material suppliers to exports For example in 1995 the capacity was used at *57 4%*, in 1996 at *47%*, in 1997 at *32 3%* The production volumes are given in Table 3 1

Production output

Table 3 1

Name of product	Unit of measure	Output			% 1997 to 1996
		1995	1996	1997	
1 Chrome leather products	thousand dm^2	221,722	181,238	124,572	68 7
2 Wet-Blue semi-finished product	thousand dm^2	35,390	62,960	61,100	97
3 Split leather	thousand dm^2	36,810	21,980	7,600	34 6
4 Total output	thousand hrivnas	**83,693**	**84,509**	**50930**	**60 3**

Analysis of the data from Table 3 1 shows that absolute volumes of output in 1996 as compared to 1995 amounted to *81 7%* for chrome leather, *178%* for Wet-Blue semi-finished product, *59 7%* for split leather, production output in comparable prices to *101%*

Accordingly, absolute volumes of output in 1997 compared to 1996 were *68 7*, *97* and *34 6%* respectively, total output *60 3%*

3 3 Prospects of development

The marketing, production and technological services of the enterprise carry out work toward the perspective development of the tannery

Plans are proceeding to change from a seller of semi-finished products into the supplier of finished goods With this purpose joint Ukrainian-Italian venture - Elisa shoe factory and Tulpan dress making shop - was set up Preparation is underway for expansion of the product range, in particular, for production of automobile and furniture leather

3 4 Exports vs Domestic sales

The tannery amalgamation exports leather Deliveries to Ukrainian enterprises and for export are shown in Table 3 2

Exports vs Domestic sales

Table 3 2

Description	Unit	1995	1996	1997
1 Exports	thousand hrivnas	24,278 3	25,047 5	16,548 3
2 Domestic deliveries	thousand hrivnas	29,673	20,138 5	28,637 7
3 Exports vs Domestic sales	%	**81 82**	**124 38**	**57 78**

Table 3 2 shows that the company has stable links at the foreign market though exports in 1997 dropped by *34*% as compared to 1996

4 0 FINANCIAL STATUS

4 1 Currency vs Barter

Barter operations at the CJSC VOZKO are significant

In 1995 they comprised 40 4%, in 1996 43 3%, in 1997 33 3% which is explained by the financial crisis in Ukraine

4 2 Viability of the plant

The primary financial results of the company operation are represented in Table 4 1 The analysis shows that the balance profit of the enterprise in 1997 was 3 times higher than in 1996, but gross income fell 1 66 times

Primary financial results

Table 4 1

Indicator	Values by years, thousand hrivnas		
	1995	1996	1997
1 Gross income	83,693	84,509	50,930
2 VAT	5,616	5,593	5,700
3 Production costs	41,355	52,116	42,436
4 Balance profit	14,106	5,579	1,791
5 Net profit	10,220	4,034	1,248

The data from Table 4 1 show that in 1997 as compared to 1996 gross income fell by *40%*, production costs by *18 6%*, which resulted in *69%* profit reduction A decrease in raw material supply caused a large fall in profit

Viability indicators shown in Table 4 2 have satisfactory values characterizing stable financial status of the tannery during the reviewed period

Indicators of financial stability

Table 4 2

Indicator	1995	1996	1997
Profitability, %	34 1	14 6	3 3

The plant has no wage or energy payment debts
All incoming and outgoing bills are collected each year and kept in the books

5 0 ANNUAL ENERGY CONSUMPTION AND COSTS

5 1 Annual consumption 1995, 1996 & 1997

The CJSC VOZKO uses primary types of energy purchased from local utilities as electric power, natural gas, potable and technical water Thermal energy as saturated steam with pressure of 5 kg/cm^2 is generated by the in-plant boiler house equipped with five boilers of DKVR - 20-13 type Annual energy consumption and costs are shown in Table 5 1 Electric power and natural gas make up accordingly ***26 65%*** and ***73 35%*** of the total consumption However, the costs relation is different electric power is ***57 76%***, natural gas– ***38 01%***, potable water is ***3 08%***, technical water - ***1 15%***

Total Energy Use by Energy Source and Cost (Based on 1997 Data)

Table 5 1

Fuel	Annual Use	Annual Use in Gcal	Share of Energy Use, %	Annual Cost, US$	Share of Annual Cost, %
Electricity	24,386 thousand kWh	20,968	26 65	1,010,658	57 76
Nat Gas	8,107 thousand m^3	57,731	73 35	665,082	38 01
Potable water	96,618 m^3	-	-	53,892	3 08
Technical water	1,027,370	-	-	20,122	1 15
Total	-	**78,700**	**100,0**	**1,749,754**	**100,0**

Fig 5 1, 5 2 show distribution of energy use and costs by the types of energy in 1997 Monthly energy use is shown in Table 5 2 and on Fig 5 3 and 5 4

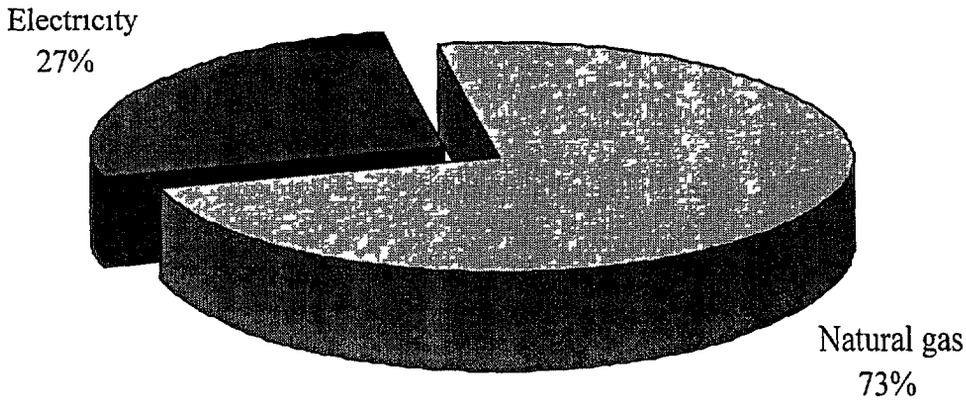
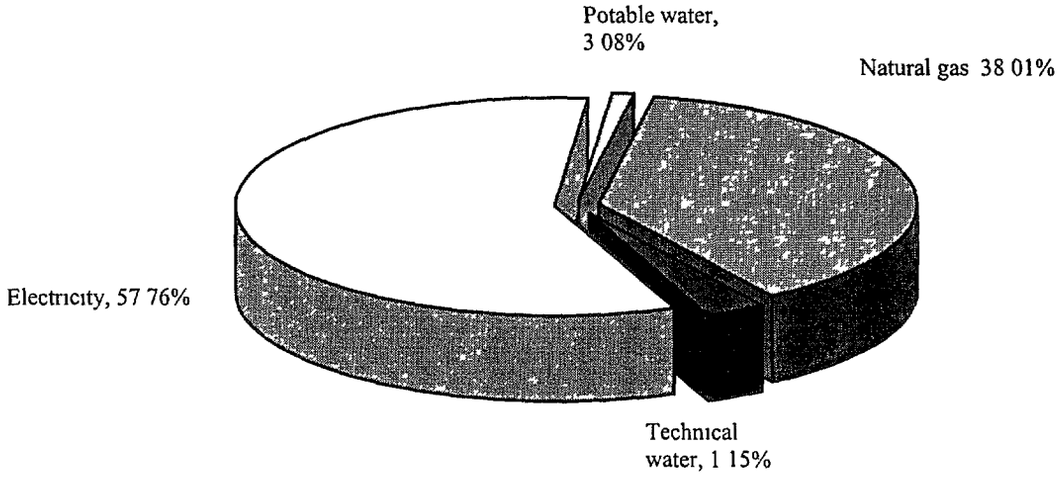


Fig 5 1 Breakdown of energy consumption



5 2 Breakdown of energy costs in 1997

Energy use at CJSC VOZKO in 1997

Table 5 2

Month of 1997	Electricity use, 1,000 kWh	Natural gas use, 1000 m^3	Water use, m^3
January	2,329	1,265	10,543
February	2,388	920	10,890
March	2,277	842	7,559
April	2,182	669	6,142
May	1,833	392	6,847
June	1,743	313	7,043
July	833	36	3,671
August	1,940	313	6,604
September	2,098	450	11,592
October	2,092	750	7,475
November	2,306	922	9,174
December	2,365	1,235	9,078
Total	**24,386**	**8,107**	**96,618**

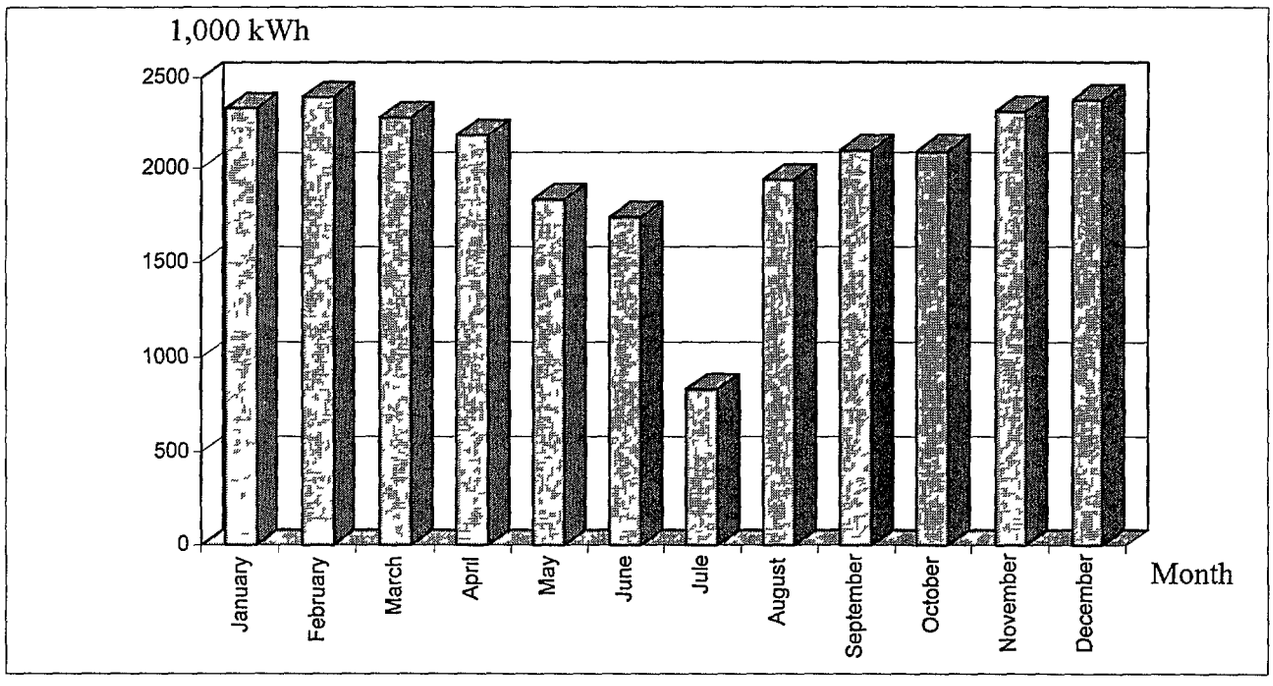


Fig 5 3 Electricity consumption

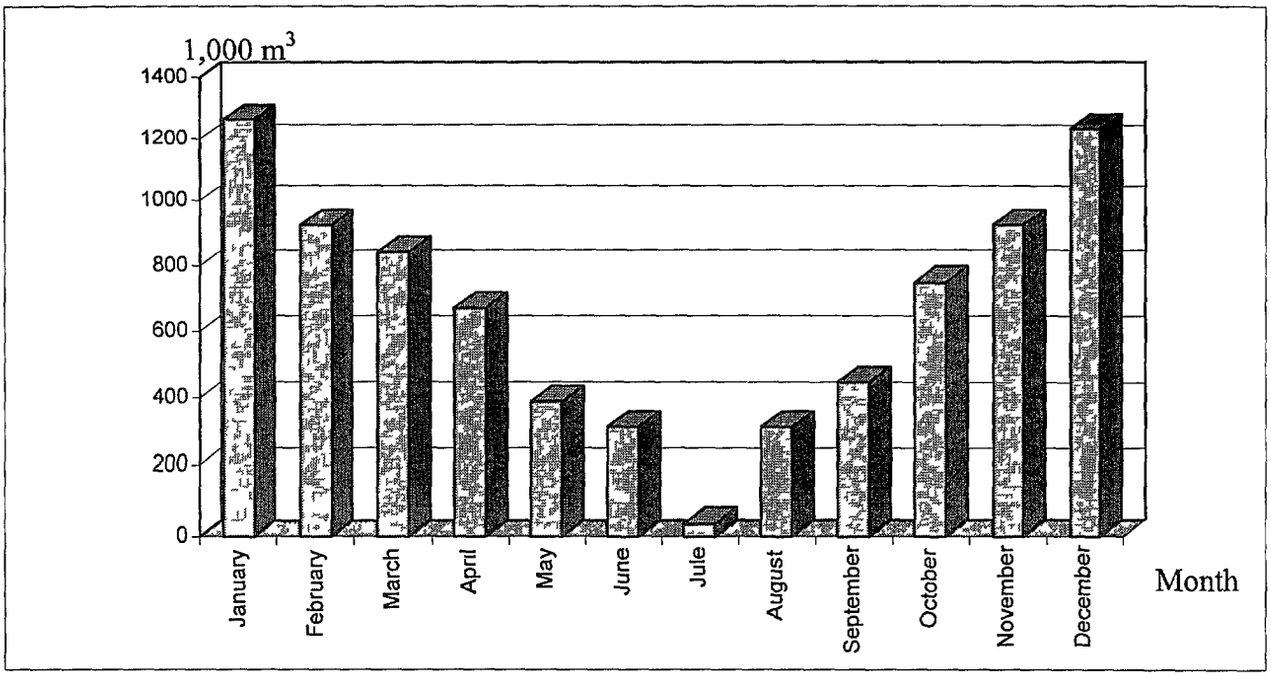


Fig 5 4 Natural gas consumption

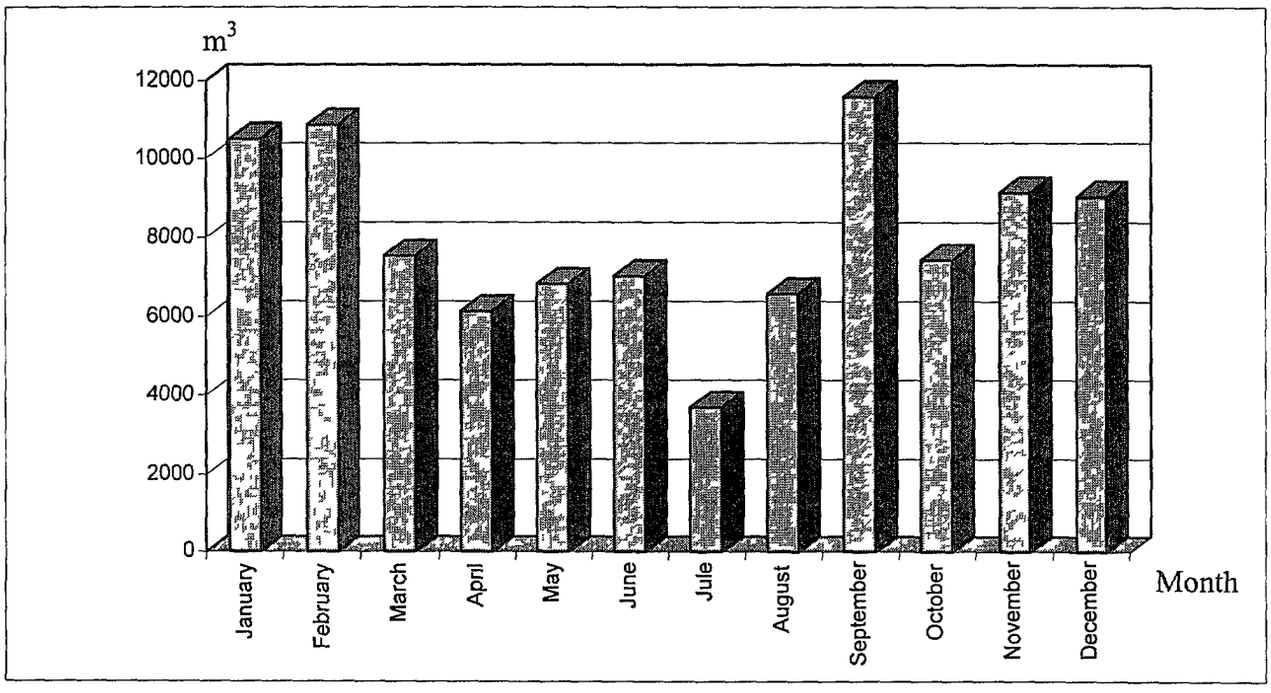


Fig 5 5 Water consumption

The total consumption of electricity in 1997 was 24,386 thousand kWh, while natural gas consumption was 8,107 thousand cubic meters and water - 96 6 thousand cubic meters The peak production period is in the 1st and 4th quarters of the year The maximum natural gas use both in 1996 and 1997 occurred in the peak production winter months and in January 1997 it was 1,265 thousand cubic meters The peak electricity, natural gas and water consumption has an obvious tendency to decrease and varies

each year depending on the delivery of hides, i e the plant operates "off-the wheels" (as they are delivered)

5 2 Current tariffs for fuel and energy

The plant pays approximately US$1,700 thousand annually for its energy consumption Energy costs run approximately 7 5 percent of the total production cost Therefore, energy efficiency measures can make a significant impact on the plant's profit

The electric rate structure is what is known as the two-part tariff with payment for consumed reactive power Once a year the plant negotiates a contract with the utility company on the rate for electric power In accordance with this contract the advance payment should be made for the negotiated amount of electric power consumption The monitoring over the consumption of contracted amount of power is carried out monthly by active and reactive power meters installed at the input feeders

The current contracted electrical rate is $3 8 per 1 kWh of negotiated demand, $0 035 per1 consumed kWh, $0 0028 per 1kVAr of consumed reactive power Average rate is US$0 048 per kWh

The natural gas comes to the plant from the city pipeline and is used mainly for generation of steam at the boiler room There are gas meters at the gas distribution unit The monthly rate for natural gas is US$83 per 1,000 cubic meters

Potable water is supplied to the plant via flow meter from the city pipeline The cost of water is US$0 897 per cubic meter

Technical water is supplied from the Yuzhny Bug at the rate of $0 0198 per cubic metre

For the in-plant settlements with sub-users the energy costs are calculated at the plant which constitute
electric power - $0 059 per kWh,
technical water - $0 075 per m^3,
thermal energy - $15 8 per Gcal

5 3 Energy use profile

The production units of the plant use the following types of energy

- electric power is supplied from the Nikolayevoblenergo utility

* main production site is supplied from two 110/10kV distribution devices and further from ten 10/0 4 kV stepdown transformers Voltage for production consumers is 380V, 50 Hz, for lighting 220V, 50Hz Rated capacity of electric equipment is 17,205 kW
* off-site facilities include water scoop at the Yuzhniy Bug river and biological treatment facilities with 4 sewer pumps located along the 15-km sewer line and are supplied from 6 stepdown transformers with total rated capacity of 8,580 kVA

- natural gas is used for steam generation and hot water supply

- at the main production site there is the boiler house with 5 DKVR-20-13 boilers with total capacity of 100 tons of steam per hour The boiler house supplies production lines with the following heat carriers - 13 kg/cm^2 steam which is reduced to 5 kg/cm^2 at the reduction and cooling unit and further on goes to

- the main production building where at the heat supply unit No 2 130-115^{0}C water is prepared at steam-to-water heaters utilized in drying, finishing and staining workshops,
- hide preparation plant,
- hide disinfectant chamber,
- local water treatment facilities to solidify sludge
- steam-to-water heat exchangers (8) in the boiler house for preparation of hot water for the ventilation and air heating system with water parameters of 150-70^{0}C

Space heating of the main production building is by air (steam coils and fans)

In the boiler house water is prepared for hot water supply with the temperature of 80^{0}C In order to build up constant static pressure this water is pumped to the water tower (h = 34 m, volume of 260 m^3) at night and utilized in daytime

Seventy per cent of condensate utilizing excess pressure after the steam trap is returned to the condensate pumping station The 65^{0}C water for domestic purposes is prepared at the condensate pumping station utilizing condensate flash heat

In soaking and liming workshop, and tanning workshop water with temperatures of 40, 30, 20^{0}C is used that is prepared in the main production building at automatic mixers

* at biological treatment facilities there is the boiler room equipped with two NIISTU-5 boilers supplying space heating, ventilation and domestic hot water systems

- potable water is supplied from the city pipeline to the storage reservoir and then is pumped to the in-site potable water network which is of ring-circuit type The pumping station is equipped with two 4K-12 pumps of 65 m^3/hour capacity, 40 m head, 17 kW electric motor,
- technical water is supplied from the Yuzhniy Bug from the first stage pumping station to the 1000 m^3 reservoir and then is pumped via the second stage pumping station to the in-site technical water network of dead-end type The pumping station is equipped with three 8K-12 pumps of 220-340 m^3/hour capacity, 25-32 m head,
- compressed air is used at the plant with pressures of 7 kg/cm^2 and 0 8 kg/cm^2 The 7 kg/cm^2 is dried and used in automatic pneumatic systems, the non-dried air is used at the chemical station, in finishing workshop (at leather staining unit), at wastewater treatment facilities, boiler house, etc Compressed air is produced by the 305VP-30/8 compressors (3 units) with 200-kW drives and VD-27/9 (3 units) with 160kW drives The controlled parameter at the compressor room is pressure in the receiver - 8 2-7 0 kg/cm^2

The 0 8 kg/cm^2 compressed air is used in the finishing workshop and leather polishing unit The air is supplied by TV-80 blowers (2 units) with 160 kW drives and RTV-80 (3 units) with 30 kW drives The capacities of blowers are not regulated

Production output in 1995 - 1997 is shown in Table 3 1, energy consumption by types of products is given on Fig 5 6, 5 7, 5 8

The plant does not submeter natural gas, thermal energy or electric consumption at production units, plants or by types of products so it is difficult to account accurately for the changes in the plants overall specific energy use Currently this accounting is carried out by the economic office of the enterprise by calculation on the basis of the design specific use per unit and production output The results if the energy and fuel use are reflected in the state statistical reporting form No 11 mtp "Report on the use of fuel, thermal energy and electric power" (Appendix D)

According to the statistics of the plant (Table 5 3, Fig 5 6) 54 8% of overall electricity use is consumption for chrome leather production

Electricity use by types of products

Table 5 3

Years	Production use, 1,000 kWh	Chrome leather production, 1,000 kWh	Wet-Blue production, 1,000 kWh	Split leather production, 1,000 kWh	Other production use, 1,000 kWh
1995	27,071	27,071	–	–	–
1996	27,876	17,549	–	–	10,327
1997	21,278	11,651	3,132	409	6,089

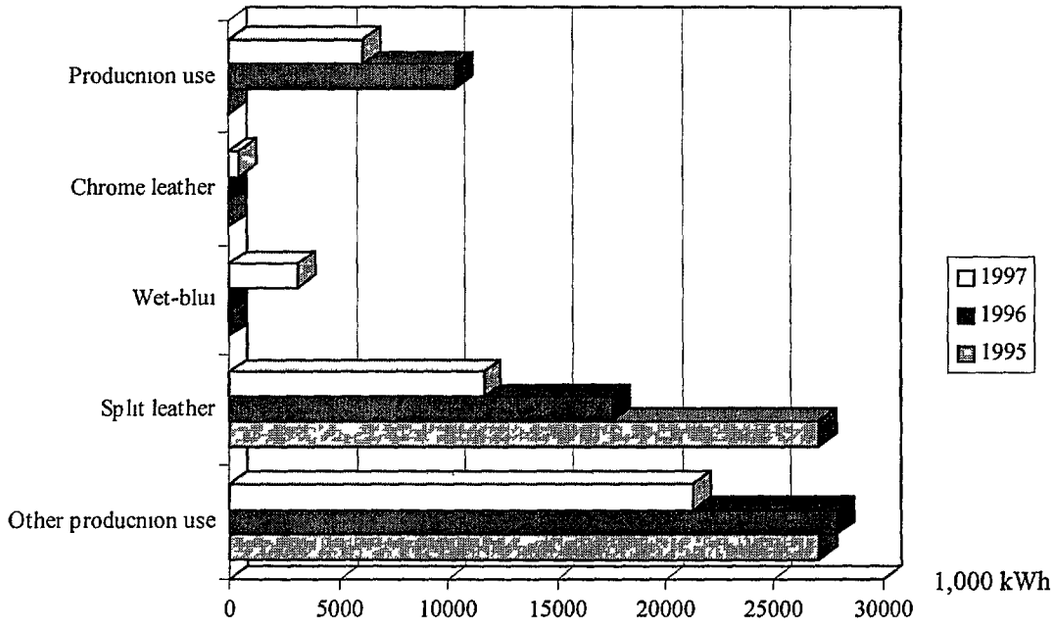


Fig 5 6 Electricity use by types of products

The natural gas consumption is driven by the demand of production units for steam and hot water Annual thermal energy consumption in 1996 was 16,878 Gcal and in 1997

9,237 Gcal The analysis of data from Tables 5 4 and 5 5, Fig 5 7 and 5 8 shows that specific fuel use was in 1995-1997 160 tce per 1 Gcal which is explained by the absence of heat generation metering

Natural gas use by types of products

Table 5 4

Years	Production consumption, tce	Heat generation, tce	Other production consumption, tce
1995	16,367	16,228	139
1996	17,023	16,828	143
1997	9,387	9,237	150

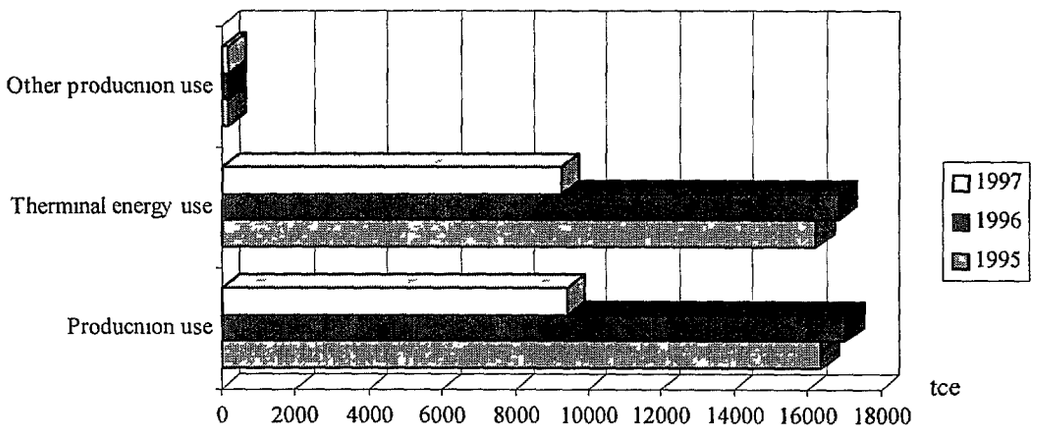


Fig 5 7 Natural gas use by types of products

Thermal energy use by types of products

Table 5 5

Years	Production use, 1,000 Gcal	Chrome leather production, 1,000 Gcal	Wet-Blue production, 1,000 Gcal	Split leather production, 1,000 Gcal	Other production use, 1,000 Gcal
1995	89 3	89 3	–	–	–
1996	100 83	66 7	–	–	34 1
1997	58 77	42 46	10 3	1 0	5 1

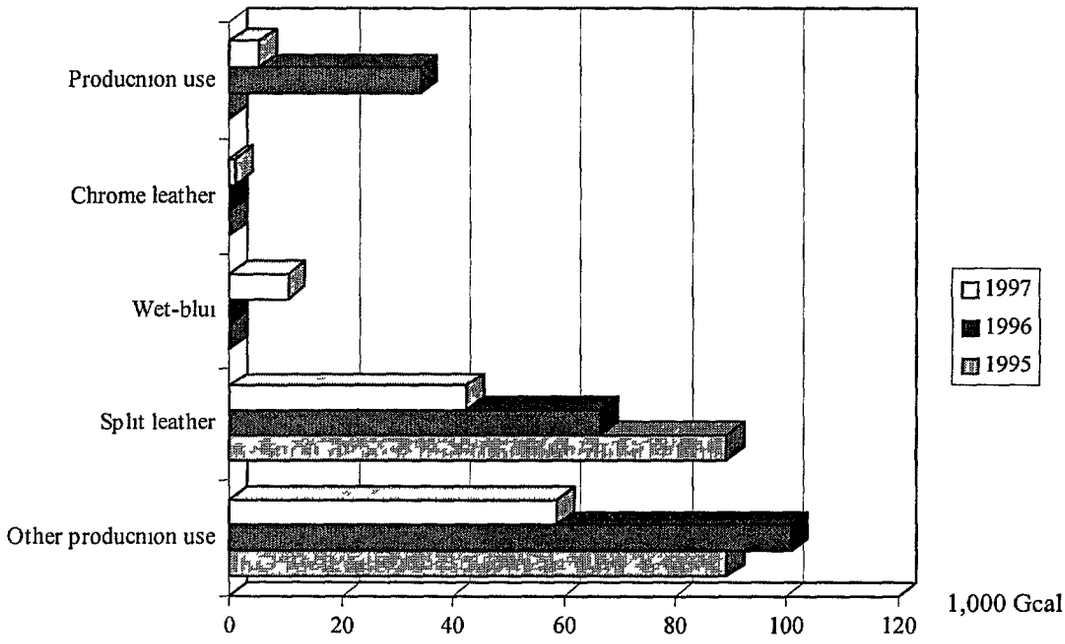


Fig 5 8 Thermal energy use by types of products

Balances of energy consumption at the JSC VOZKO are shown on Fig 5 9 – 5 10

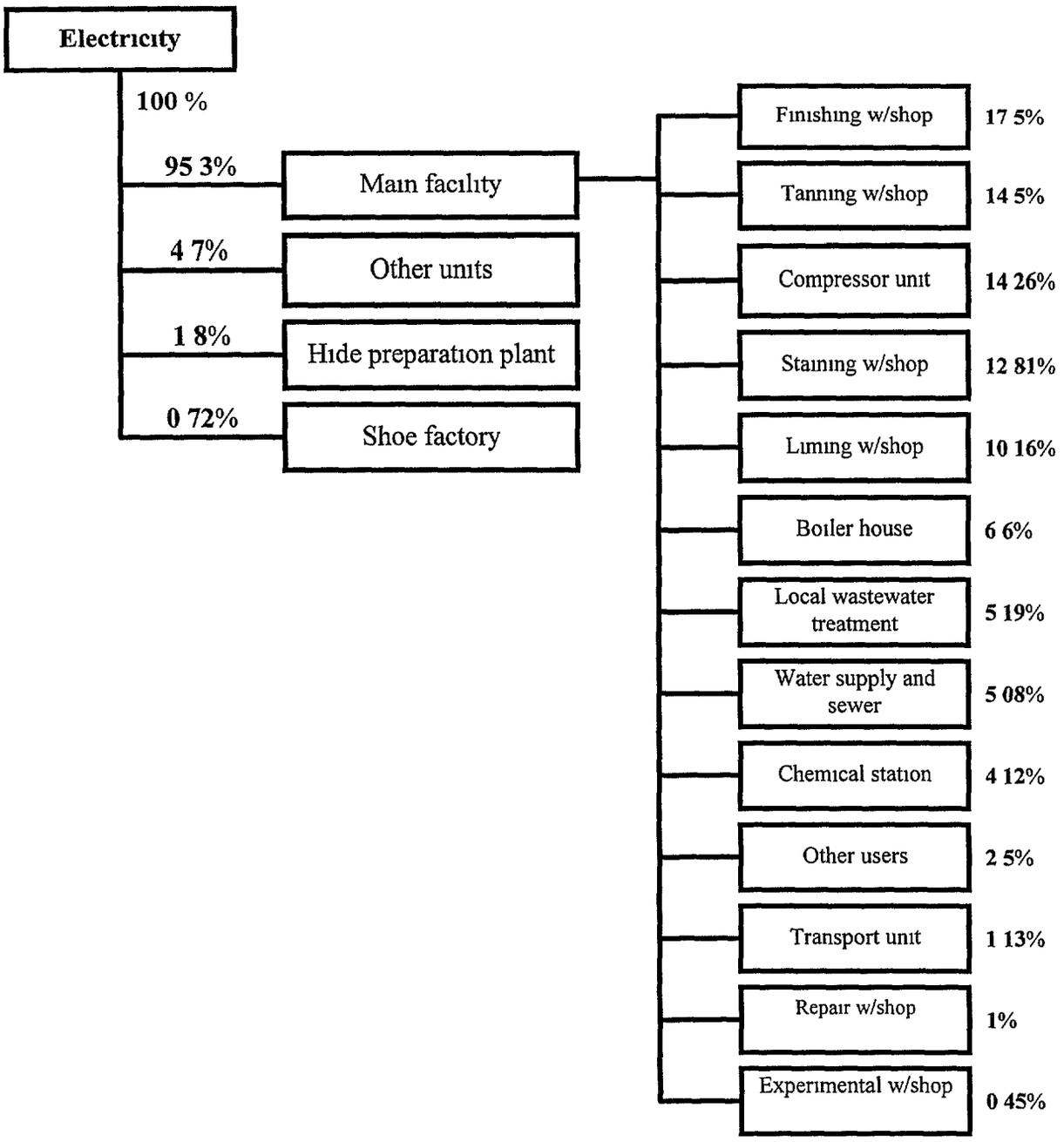


Fig 5 9 Balance of electricity use at the CJSC VOZKO

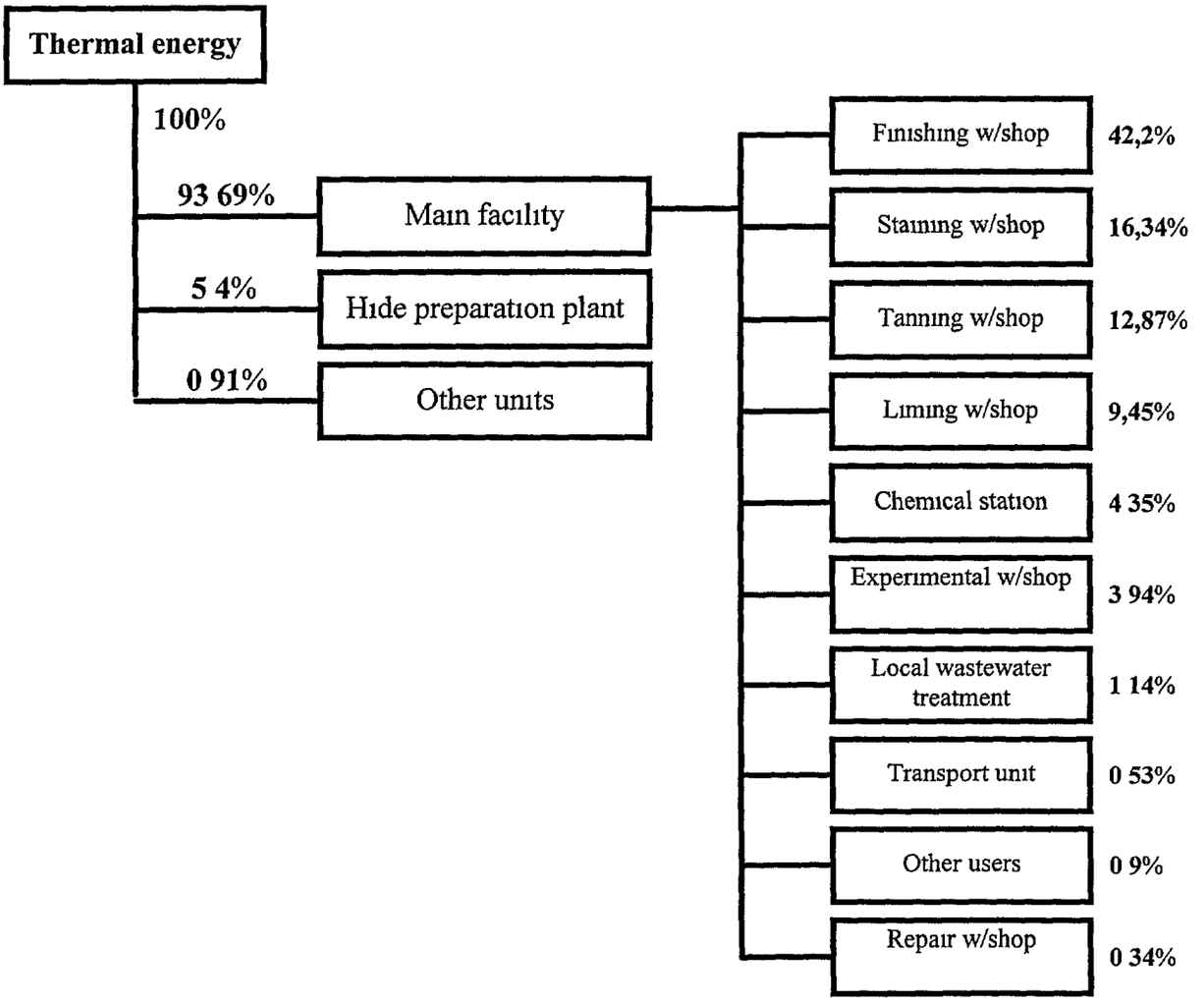


Fig 5 10 Balance of thermal energy use at the CJSC VOZKO

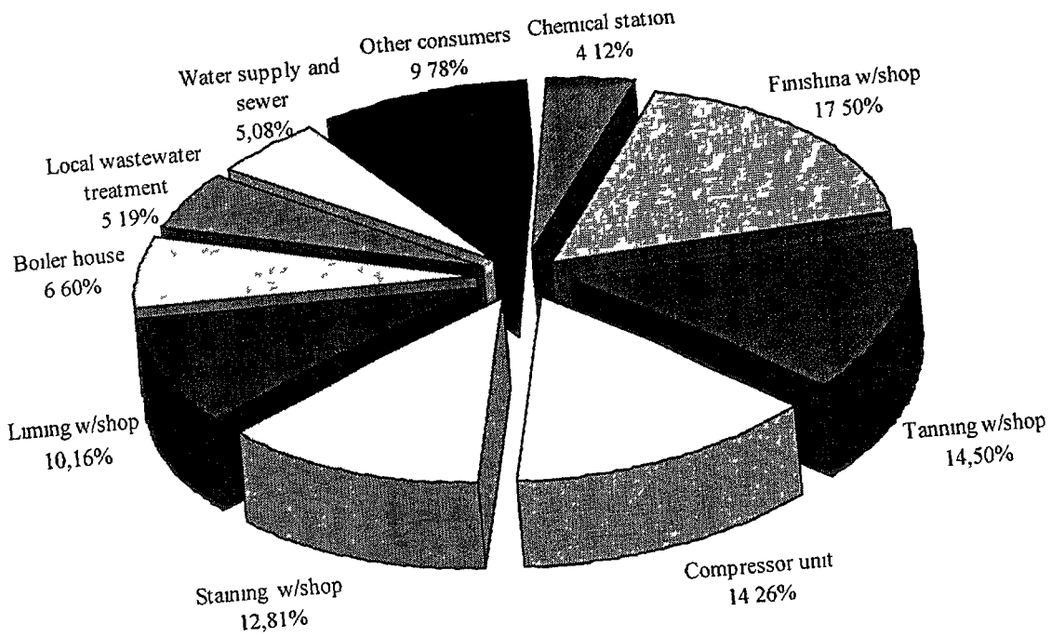
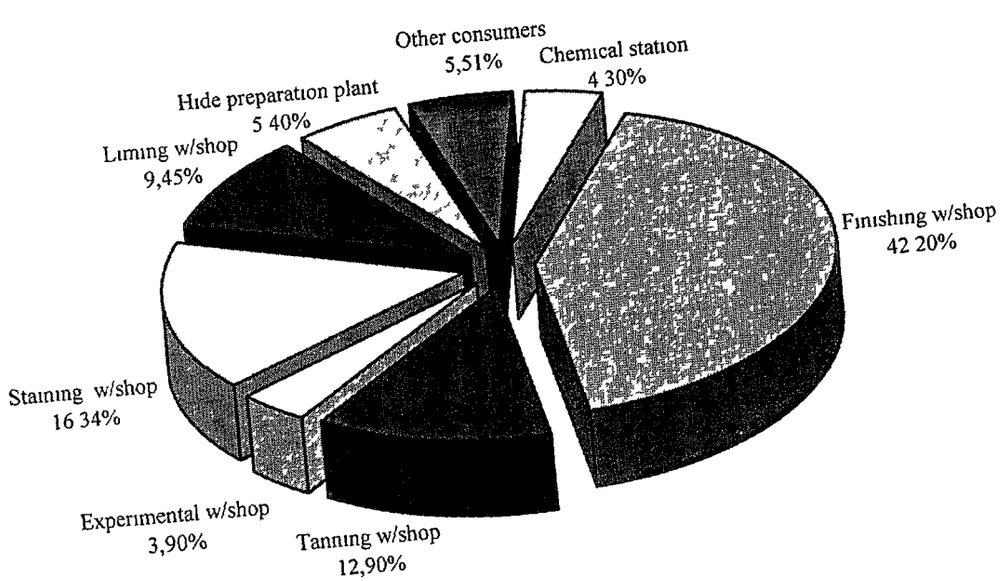


Fig 5 11 Breakdown of electricity use by company units



5 12 Breakdown of thermal energy use by company units

6 0 PREVIOUS ENERGY IMPROVEMENTS

Certain work on implementation of energy conservation measures is being carried out at the tannery

- Comprehensive energy conservation program at the CJSC VOZKO for 1997-2010 has been developed

- Specific energy consumption standards per unit of production in 1998-1999 have been worked out

- Unused transformers are cut off from the power supply system

- Thermal insulation of main steam-, hot water- and condensate piping have been repaired This work is carried out on regular basis

- At sewer pumping stations sewer pumps are replaced with lower capacity pumps for operation during days-off and in nighttime

- Exhaust ventilation has been renovated by replacement of exhaust fans with deflectors, etc

The company develops the "Energy consumption" automatic control system based on computerized technologies

Tanning technologies are being improved with the view of reduction of energy consumption

7 0 ENERGY AUDIT

The analysis of the fuel and energy use by the tannery described in section 5 of this report and the study of the actual use of the energy resources resulted in development of the energy conservation opportunities (ECO) viewed below which will reduce electricity consumption by 6,247,700 kWh (25 4% of 1997 consumption) and natural gas consumption by 3,198,700 m^3 (48 3%)

These ECOs can be applied at other industrial enterprises with similar conditions

ECO - 1 Institution of energy management

Energy management is the main avenue by which energy usage reduction and increase in consumption efficiency can be achieved This management strategy is based on conventional measurements and documentation and provides operating conditions that facilitate minimal energy consumption needed for the technology

Implementation of energy management program will result in having more detailed energy consumption records Such system will allow comparison of the energy usage to that of other enterprises for precise evaluation of energy saving projects that are considered by the facility

We recommend to introduce at the plant the energy management program to full extent The implementation of this ECO will result in reducing energy consumption by 5%

Currently the plant uses annually on average 24,386,000 kWh of electric power and 8,107,000 m^3 of natural gas The global experience and practice show that in case of institution of full-time energy management ensures 5% of fuel and energy consumption savings Energy savings will amount to
1) Electric power - 2,438,000 x 0 05 = 1,222,000 (kWh)
2) Natural gas - 8,107,000 x 0 05 = 405,350 (m^3)

Total cost of instituting energy management will be $85,100
Simple payback period will be 0 92 year (11 months)
See details in Appendix A 1, ECO # 1

ECO #2 Increase of reactive power compensation in the plant power supply system

The plant uses physically worn-out means of reactive power compensation in the power supply system resulting in the power factor being significantly lower than the design value Low power factor results in electricity losses

We recommend to install automatically controlled means of reactive power compensation

Implementation of the ECO will result in reduction of power losses in the grids by 1,000 thousand kWh, besides, reactive power costs will drop by $30,020

In order to ensure reactive power compensation at the design value of the power factor given the real workload of the enterprise it is necessary to install power factor capacitors of total capacity of 2,000 kVAr with automatic control Cost of equipment and construction will be approximately $100,000

Simple payback = 3 3 years
See details in Appendix A 2, ECO # 2

ECO #3 Installation of steam trap units at the steam consuming systems

At the plant the 5 kg/cm^2 steam is used for heating water to 130-115^{0}C at the No 2 heating unit of the main production building, at local wastewater treatment facilities, at hide shreds boiling unit, for space heating and ventilation using 8 network heat exchangers water is heated to 150-70^{0}C

As the energy audit results showed that 3 steam traps are installed at the No2 heating unit (three of them), in the boiler house out of 8 heat exchangers only one is equipped with a steam trap, steam utilizing equipment at the local wastewater treatment facilities and in the soaking and liming workshop at the hide shreds boiling unit (4 boiling pans) is not equipped with steam traps resulting in the unused steam with the condensate at 114^{0}C going to the condensate pumping station is lost into the atmosphere as flash steam, at wastewater treatment facilities and hide shreds boiling unit it is drained into sewer

We recommend to install steam trap units at the above mentioned equipment to reduce the steam and condensate waste

Annual energy savings will be 1,325 7 Gcal (197,000 m^3 of natural gas), cost savings will be S_c = $41,905

Total implementation cost will be $ 9,936

Simple payback = 0 24 years

See details in Appendix A 3, ECO # 3

ECO # 4 Insulation of steam and hot water piping

As the result of the study of the steam distribution system it was established that despite thermal insulation of main steam pipelines, branch pipes and condensate pipelines do not have proper insulation

It is recommended that the steam and hot water piping should be fully insulated

The annual thermal energy savings should amount to ***1,510*** Gcal/year (***224*** thousand m^3 of natural gas)

Annual cost savings due to reduction of thermal energy consumption will be ***US$23,858***
Implementation cost will be ***US$4,869***

Simple payback =*02 year*
See details in Appendix A 4, ECO # 4

ECO #5 Improvement of combustion efficiency in DKVR-2 5-13 boiler by excessive air control

For thermal energy supply 5 DKVR-20-13 boilers are used (one or two are in operation, the rest are standby) To run these boilers the operation charts have been worked out but automatic control of fuel-to-air ratio in conformity with the load is nonexistent The air consumption value is controlled periodically by the supply air pressure and gas consumption by the pressure before the burners which under the conditions of uncontrolled air infiltration does not allow one to substantiate the idea of optimal combustion processes Control of optimal combustion is carried out by subjective perception of the flame color by the boiler operator

We recommend to equip the operation personnel of the boiler unit with the ENERAC-2000 or BACHARACH combustion analyzer and to include in the operational responsibilities of the operator periodical check of combustion processes which would ensure the increase of boiler combustion efficiency and savings in natural gas

Introduction of this measure will reduce the specific use by ~*6%* and it will reach 162 34 kg per 1 Gcal, average boiler efficiency will rise to *88*%

Savings of gas will be *477 8* thousand cubic meters, cost savings will be ***US$39,660***, implementation cost will be ***US$6,500***

Simple payback will be *0 16* year

See details in Appendix A 5, ECO # 5

ECO #6 Energy efficient plant lighting

The external lighting system of the plant area consists of 82 SKZPR-250 lighting fixtures with DRL - 250 high pressure mercury lamps installed on 9-meter high ferroconcrete lampposts Part of the area adjacent to the production buildings is lighted by conventional 200-watt and 500-watt incandescent lamps The light flow of the DRL-250 lamp is equal to 10,000 lumen and the nominal service life is 2,400 hours

It is suggested to consider the proposal of replacement of DRL -250 high pressure mercury lamps for external lighting of the plant area with the DNaT-100-3 high pressure sodium lamps using existing fixtures and replacing switching appliances with appropriate capacity The sodium lamps of the DNaT -100-3 type manufactured in the city of Poltava have a longer operation life - 6,000 hours with the light flow of 9,000 lumen

Annual energy savings by using DNaT-100-3 lamps will be *57,764* kWh

Cost savings at the price of electric power of US$0 048 per 1kW will be ***US$2,772 7***

Implementation costs will be US$*2,460*

Simple payback will be *0 9 year*

See details in Appendix A 6, ECO # 6

ECO # 7 Utilization of steam reduction energy for electric power co-generation

The heat supply layout of the boiler house is designed for generation of thermal energy as steam by the DKVR-20-13 boilers with successive reduction of steam pressure at the pressure reduction plant (PRP) to 5 atm which is rated for handling 60 tons of steam per hour There are two such PRPs at the boiler house

Given the actual load of the boiler house during the audit we recommend to install two electric generators of PVM-250-EG type parallel to one of the PRP to utilize previously lost steam pressure energy

In case of round-the-clock operation of the boiler house the generation plant will work 24 hours a day and 5,000 hours a year

Total amount of generated electricity will be *2,500 000* kWh

Cost savings due to reduction of electric power consumption from the regional utility will be *$120,000* per year

Simple payback will be *1 04* years
See details in Appendix A 7, ECO # 7

ECO # 8 Infrared heating with direct combustion of natural gas

The plant uses air space heating of the main production building with induced ventilation The maximum design heat use is 0 272 Gcal/hour By the data of the plant for this purpose 20 2 thousand Gcal of heat is used Since the plant is not operating to full capacity some of the heat is not used rationally as the entire building is heated not just workplaces

We recommend to install infrared systems with direct combustion of natural gas above workplaces in the liming, tanning, staining, drying water treatment workshops The recommended systems have certain benefits over conventional systems

We recommend to utilize high- and low-rate ***Schwank*** heaters using low-pressure natural gas

Equipment cost is $*70,200*

Natural gas savings will be *1,650,000* m^3

Cost savings will be $*205,730*

Simple payback will be *0 92 year* i e the ECO will payback in 2 heating seasons
See details in Appendix A 8, ECO # 8

ECO # 9 Automatic energy metering system

The enterprise uses several types of energy and fuel electric power, gas, steam, compressed air and technical water

The detailed study showed that calculations of steam, electric power, gas, compressed air, hot and cold water consumption by separate production units of the tannery are made by standard indicators and actual production output figures Instrument metering is non-existent

We recommend to automate commercial and technical metering using the ITEK technical instruments manufactured by the Energiya R & D institute in Kiev These instruments are certified in Ukraine and are designed for continuous and periodical measurement/registration of physical values

In order to implement the ECO it is planned to set up commercial metering of power consumption at 8 points, commercial gas metering at 1 point and of technical water at 2 points

Technological metering of electric power will be implemented at 60 points, hot technical water at 6 points, technical water at 8 points, steam at 11 points, compressed air at 3 points, gas at 5 points, condensate at 1 point

Judging from the experience with other plants expected savings from introduction of own automatic metering at the plant and energy use planning and control system will be not less than 5% Therefore, based on the 1997 data annual savings of natural gas will be 405 thousand m^3 , of electric power - 1,000 thousand kWh, cost savings - $8,500, implementation cost - $1150,000
Construction and installation costs - = 30,000

Simple payback will be ***1 8 years***
See details in Appendix A 9, ECO # 9

ECO # 10 Introduction of air curtain blocking while opening gates of the main building

The gates of the main building are equipped with a system of hot air curtains to prevent infiltration of cold air inside while the gates are open However, the audit resulted in finding that the above mentioned systems work round the clock during the heating season

We recommend to add to the system of air curtains an automatic blocking feature to be used to turn on air curtains when the doors are opened and turn off fans and thermal supply to air heaters while the gates are closed

Total heat savings will be ***3,380*** Gcal (***502,000*** cubic meters of gas), fuel cost savings will be ***60,647*** $ per year, implementation cost ***5,000*** $

Simple payback will be ***0 08*** year
See details in Appendix A 10, ECO #10

ECO # 11 Replacement of single-pane windows in the main building with double-pane

In conformity with the State construction standards the windows of industrial buildings should be double As the audit showed double-pane windows are not installed overall in the main production building 1,500 m^3 of windows have been replaced with double-pane ones with aluminum framing that reduced significantly the heat waste by increase of the thermal resistance and by lowering of the infiltration However, the tannery has 600 m^2 of single-pane windows and the recommended work should continue Additionally, we recommend to consider replacement of single-pane ceiling windows over certain premises at X-Y axis in the building layout plan, particularly, in the sorting and measurement units

Annual heat savings – ***104*** Gcal (***15 4*** thousand m^3 of gas)

Annual cost savings at the price of *1* Gcal of heat will be ***15 8***$ will be ***1,643*** $ per year Cost of materials and glass ≈ ***6,500***$

Simple payback will be ***4 0*** years

See details in Appendix A 11, ECO #11

ECO # 12 Monitoring of boiler equipment operation and temperature modes of heat-consuming equipment

The tannery has an extensive steam and condensate heating system, however, in-built control pressure gauges and thermometers are practically absent It is impossible to perform an analysis of the efficiency of heat-using equipment, to calculate specific consumption and to promptly discover equipment deficiencies

We recommend to introduce at the plant a portable infra-red thermometer of ***"Reynger ST6"*** type that will enable monitoring of the heat consuming equipment and to supervise it regularly (***1 - 2*** times a week) the efficiency of its operation and to react promptly to the thermal energy wastes Expected efficiency improvement of the heat use is ***0 3–0 6%***

Estimated thermal energy savings will be ***288 6*** Gcal that makes ***41 9*** thousand m^3 of natural gas, cost savings will be $***4,560,*** implementation cost $***1,000***

Simple payback will be ***0 22*** year
See details in Appendix A 12, ECO #12

ECO # 13 Monitoring of electric motor capacities and electric power use

Approximately ***87***% of total electricity use of the tannery are used for production purposes according to the 1997 data which amounts to ***21,278*** thousand kWh to the sum of ***1,022,000***$

Some of the primary consumers of electric power are electric motor drives of production, pumping and ventilation equipment

Previously in case of motor failures they were replaced with disregard to the nominally required capacity As the measurements at the tanning workshop, compressor room, water pumping stations and at ventilation fans showed the rated capacity of electric motors is used at ***30–40%*** Even similar equipment uses various capacity motors often exceeding the needs The total rated capacity of 210 motors at the production lines is ***1,805*** kW

We recommend motor operation be monitored (first and foremost, motors of compressors, pumps and fans) with the help of portable instrument set of ***Clamp-on Digital Wattmeter*** and ***Power Factor Meter*** The recommended measure will allow monitoring of the actual motor loads, analyze the efficiency and organize replacement with more efficient motors Implementation of this project will save not less than ***1,5%*** of electric power used for production purposes annually

Energy savings estimate is ***319,000*** kWh, cost savings estimate is $ ***15,312***, implementation cost is $***6,500***

Simple payback is ***0 43*** year

See details in Appendix A 13, ECO #13

8 0 ENVIRONMENTAL IMPACTS OF RECOMMENDATIONS

The most efficient way of reduction of hazardous emission in the atmosphere is the decrease of fuel and electric power use In section 7 calculations have been made supporting opportunities of thermal energy, natural gas and electric power savings

Since the tannery meets the requirements for thermal energy using the in-plant boiler house the savings are shown as natural gas savings

Thermal energy savings from implementation of the proposed measures for the entire plant will amount to

ECO #1 - S_{1g} = 405 3 thousand m^3 per year
ECO #3 - S_{3g} = 197 thousand m^3 per year
ECO #4 - S_{4g} = 224 3 thousand m^3 per year
ECO #5 - S_{5g} = 477 8 thousand m^3 per year
ECO #8 - S_{8g} = 1,650 thousand m^3 per year
ECO #9 - S_{9g} = 405 thousand m^3 per year
ECO #10 - S_{10g} = 502 thousand m^3 per year
ECO #11 - S_{11g} = 15 4 thousand m^3 per year
ECO #12 - S_{12g} = 41 9 thousand m^3 per year

Total natural gas savings will be $S_{sum} = S_{1g} + S_{3g} + S_{4g} + S_{5g} + S_{8g} + S_{9g} + S_{10g} + S_{11g} + S_{12g}$ = 405 3 + 197 + 224 3 + 477 8 + 1,650 + 405 + 502 + 15 4 + 41 9 = 3 918 7 thousand m^3 per year

Natural gas combustion leads to emission into the atmosphere of carbon oxide CO and nitrogen oxides NO_X

The amount of prevented emission we determine using combustion efficiency study (Appendix D) of No1 boiler that shows the following emissions

- carbon oxide emission - $M_{CO} = h_{CO} \, x \, S_{sum\ gas} + (h_{CO} - h^1_{CO}) \, x \, (N_g - S_{sum\ gas})$= 0 08 x 3,918 7 + (0 08 -0 05) x (8,113 - 3,918 7) = 440 kg,

- nitrogen oxide emission - $M_{NOx} = h_{NOx} x \, S_{sum} + (h_{NOx} - h^1_{NOx}) \, x \, (N_g - S_{sum\ gas})$= 0 377 x 3,918,7 + (0 377 - 0 233) x (8,113 - 3,918 7)= 2,080 kg,

where h_{CO}, h_{NOx}, h^1_C, h^1_{NOx} are specific emissions of carbon oxide and nitrogen oxides before and after implementation of ECO #5, kg/1,000 m^3

Electric power savings from implementation of the proposed measures for the entire plant will amount to
ECO #1 - W_1 = 1,220 thousand kWh,
ECO #2 - W_2 = 1,000 thousand kWh,
ECO #6 - W_6 = 57 8 thousand kWh,
ECO #7 - W_7 = 2,500 thousand kWh,
ECO #9 - W_9 = 1,000 thousand kWh,

ECO #10 - W_{10} = 150 9 thousand kWh,
ECO #13 - W_{13} = 319 thousand kWh,

Total electric power savings will be $W_{sum} = W_1 + W_2 + W_6 + W_7 + W_9 + W_{10} + W_{13}$ = 1,220 + 1,390 + 57 8 + 2,500 + 1,000 + 150 9 + 319 + = 6,247 7 thousand kWh per year

According to the data of the Ministry of energy of Ukraine in 1996 average emissions from generation of 1 thousand kWh were as follows

emissions of solid particles - 4 4 kg,

carbon oxide CO - 0 5 kg,

nitrogen oxides NO_X - 2 2 kg,

sulfur oxides SO_2 - 9 9 kg

The results of prevented pollutant emission into the atmosphere through electric power and natural gas savings are shown in Table 8 1

Summarized indicators of prevented pollutant emission into the atmosphere as the result of proposed ECO implementation

Table 8 1

Type of emission	Reduction through thermal energy savings	Reduction through electric power savings	Total reduction per year
Solid particles, tons		27 5	27 5
Carbon monoxide, tons	0 44	3 12	3 56
Nitrogen oxides, tons	2 08	13 75	15 83
Sulfur oxides, tons		61 86	61 86

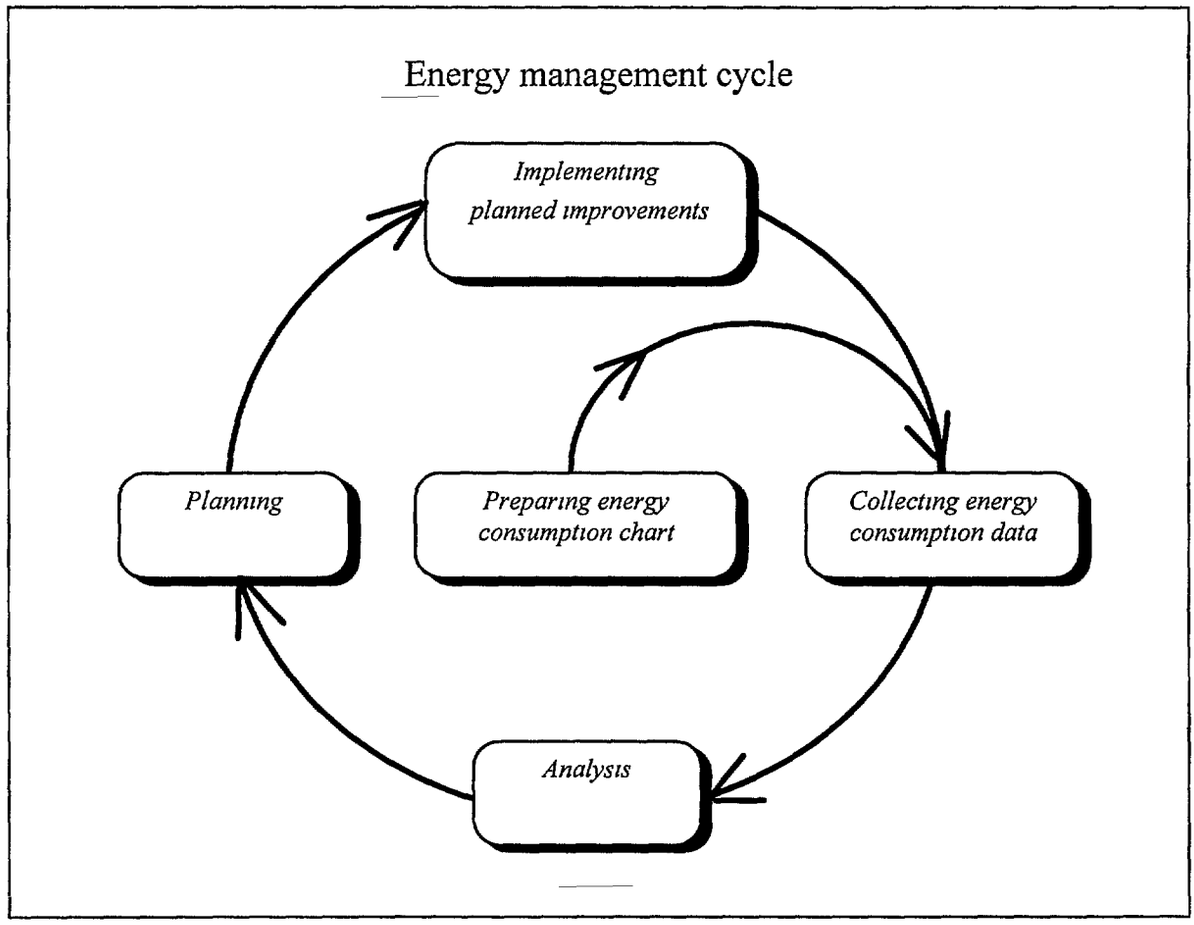
Thus implementation of proposed measures will cut down pollutant emission into the atmosphere by 108 75 tons That will improve ecological situation in the town of Voznesensk

APPENDIX A ENERGY CONSERVATION OPPORTUNITIES (ECO)

A 1 ECO - 1 Institution of energy management

ECO description

Energy management is the main avenue by which energy usage reduction and increase in consumption efficiency can be achieved This management strategy is based on conventional measurements and documentation and provides operating conditions that facilitate minimal energy consumption needed for the technology This is also a management tool which comprises a continuous research allowing precise knowledge on facility's energy distribution and consumption, as well as on best energy utilization for production, district heat and other non-productive purposes



Implementation of energy management program will result in having more detailed energy consumption records Such system will allow comparison of the energy usage to that of other enterprises for precise evaluation of energy saving projects that are considered by the facility

Energy management program starts with appointing an energy manager, the person responsible for implementation of the program and appointed by the plant's administration The main duties of an energy manager include

- Participation in preparing facility's energy consumption chart (probably in collaboration with an outside consultant, energy auditor),
- Training the plant personnel in energy management practices,

- Collecting fuel and energy consumption data using measuring and testing equipment,
- Preparing a plan for implementing additional measuring and testing equipment,
- Collecting data on raw materials and energy consumption and on production output,
- Making key calculations on improving energy efficiency - for overall facility as well as specific production lines,
- Development and implementation of energy conservation measures requiring no or minimum investment and prioritizing capital-intensive measures,
- Participation in the enterprise production and strategical planning,
- Implementing new technologies on existing and new energy systems to improve energy efficiency of operation,
- Keeping informed on current energy policy trends and neighboring issues, (e g , such as new tax legislation, existing consumption restrictions, subsidies, environmental aspects etc)

We recommend to introduce at the facility the energy management program to full extent The implementation of this ECO will result in reducing energy consumption by 5%

In order to enhance objectivity of energy management is necessary to develop and implement energy consumption record keeping system with transcription of electric meters indications on all transformer substations according specific timetable Current system only records plant overall electric consumption according the timetable, for internal users only occasional data is available

It is necessary to develop a system of energy metering utilizing modern computerized technology that will permit to evaluate the dynamics of energy consumption for production purposes and work out energy conservation recommendations

Annual energy savings

According to 1997 data the plant uses annually on average 24,386,000 kWh of electric power and 8,107,000 m^3 of natural gas The global experience and practice show that in case of institution of full-time energy management ensures 5% of fuel and energy consumption savings Energy savings will amount to
1) Electric power - 24,386,000 x 0 05 = 1,222,000 (kWh)
2) Natural gas - 8,107,000 x 0 05 = 405,350 (m^3)

Annual cost saving estimate

1 At the price of $0 048 per 1 kWh of electric power the cost savings will be
1,220,000 x 0 048 = $58,600
2 At the price of $0 083 per 1 m^3 of natural gas the cost savings will be
405,350 x 0,083 = $33,600
Total fuel cost savings will be
58,600 + 33,600 = $92,200

Implementation Costs

According to the world practice, expenses on implementing energy management are planned in advance and constitute 5% of energy costs These expenses include costs of improving energy consumption record system, management costs, costs of consulting company services, which will produce

- facility's energy flow survey,

- energy consumption charts,
- energy consumption balance,

and will also

- develop energy efficiency recommendations,
- implement energy management program,
- provide assistance in purchasing energy efficient equipment

At average annual energy costs (at 1997 prices) of $1,701,423 total implementation costs of energy management program will be

1,701,423 x 0 05 ~ ***$85,100***

Simple payback

Implementation costs - $85,100
Annual cost savings - $92,200
Simple payback period will be
85,100/92,200 = ***0 92*** year (***11*** months)

A 2 ECO #2 Increase of reactive power compensation in the plant power supply system

ECO description

The plant uses physically worn-out means of reactive power compensation in the power supply system resulting in the power factor being significantly lower than the design value ($\cos\phi$ = 0 975 at the 0 4 kV side with compensation and 0 94 at the 10 kV side) constituting in accordance with the plant load measurements (Appendix D) in the summer $\cos\phi_s$ = 0 723, in the winter = $\cos\phi_w$ = 0 62 The load chart of measurements at the supply line to the drum unit of the tanning workshop on 25-26 march 1998 (Appendix D) shows that that the natural $\cos\phi$ varies within $\cos\phi$ = 0 22 - 0 92 Low power factor results in electricity losses

We recommend to install automatically controlled means of reactive power compensation

Annual energy savings estimate

Reduction of power losses in the supply grids by increasing the power factor will amount to

$S = k \times (W_{r1} - W_{r2})$ = 0 08 x (17,395 - 4,928) = ***1,000*** thousand kWh

where W_{r1} is consumption of reactive power before the introduction of the ECO at average $tg\phi$ = 0 8149 thousand kVAr,
W_{r2} is consumption of reactive power after the introduction of the ECO at average $tg\phi$ = 0 23 thousand kVAr,
k is the economic equivalent of reactive power, k = 0 08 kW/kVAr

The electric power consumption indicators at the CJSC VOZKO in 1997 are shown in Table A 2 1 based on the plant data

Table A 2 1

Indicator	Unit	Value of indicator	
		1997 actual	after introduction
1 Consumption of active power	mln kWh	21 346	21 346
2 Consumption of active power	mln kVArh	17 395	4 93
3 Power factor, $tg\phi$	–	0 8149	0 2309
4 Payment for reactive power	$ US	41,890	11,870

Implementation of the ECO will result in reduction of power losses in the grids by 1,000 thousand kWh, besides, reactive power costs will drop by $30,020 (see Table A 2 1)

Implementation costs

In order to ensure reactive power compensation at the design value of the power factor of tgϕ = 0 23 it is necessary to install power factor capacitors of total capacity of 2,000 kVAr with automatic control Cost of equipment and construction will be approximately ***$100,000***

Simple payback

Annual cost savings - S_c = $30,020 per year

Implementation costs - C_1 - $100,000

Simple payback
$SP = C_t / S_c$ =100,000/30,020 = ***3 3*** years

A 3 ECO #3 Installation of steam trap units at the steam consuming systems

ECO description

At the plant the 5 kg/cm^2 steam is used for heating water to ***130-115***^{0}C at the No2 heating unit of the main production building, at local wastewater treatment facilities, at hide shreds boiling unit, for space heating and ventilation using 8 network heat exchangers water is heated to ***150-70***^{0}C

As the energy audit results showed that 3 steam traps are installed at the No2 heating unit, in the boiler house out of 8 heat exchangers only one is equipped with a steam trap, steam utilizing equipment at the local wastewater treatment facilities and in the soaking and liming workshop at the hide shreds boiling unit (4 boiling pans) is not equipped with steam traps resulting in the unused steam with the condensate at 114^{0}C going to the condensate pumping station is lost into the atmosphere as flash steam, at wastewater treatment facilities and hide shreds boiling unit it is drained into sewer

We recommend to install steam trap units at the above mentioned equipment which will reduce steam and condensate waste by 10-15%

Annual energy savings estimate

We estimate that the steam saved will be 10% annually

The results of calculations are presented in Table A 1 1

Table A 1 1

Locates of steam traps	Annual steam consumption, Gcal	Energy savings, Gcal	Cost of 1 Gcal, $	Energy savings, $
1 Local wastewater treatment	257	25,7	31 61	
2 Network HX in the boiler room of space heating and ventilation system (considering use of infrared heating)	12,600	1,260	31 61	
3 Hide shreds boiling	400	40	31 61	
Total		**1,325 7**	**31 61**	**41,905**

Annual energy savings will be 1,325 7 Gcal (197,000 m^3 of natural gas), cost savings will be S_c = $***41,905***

Implementation cost

We recommend to install 7 steam trap units equipped with the following ***Spirax Sarco*** products

Location of steam trap units	Pcs	Complete steam trap unit		
		Float-type steam trap	Trap strainer	Check valve
1 Local wastewater treatment	2	DN 20 FT 20-32 cost **360 $**	DN 20 Fiq 33 cost **90 $**	–
2 Network HX in the boiler room of space heating and ventilation system	3	DN 20 FT 14 cost **1200 $**	DN 25 Fiq 33 cost **110 $**	DN 25 DCV cost **160 $**
3 Hide shreds boiling	2	DN 20 FT 20-32 cost **360 $**	DN 20 Fiq 33 cost **90 $**	–
Total cost	**7**	**5040 $**	**690 $**	**480 $**

Total equipment cost, shipping included

$6,120 x 1 3 =$8,073

Installation costs (assumed 30% of equipment cost)

$6,210 x 0 3 = $1,863

Total implementation costs

C_i = 8,073 + 1,863 = $9,936

Simple payback

Annual cost savings - S_c = $41,905 per year

Implementation costs - C_i - $9,936

Simple payback
$SP = C_i / S_c = 9\ 936/41{,}905 = 0\ 24$ years

A 4 ECO # 4 Insulation of steam and hot water piping

ECO description

As the result of the study of the steam distribution system it was established that despite thermal insulation of main steam pipelines several branch pipes and condensate pipelines do not have proper insulation

Particulars of broken insulation and non-insulated piping after taking measurement are given in Table A 4 1

Table A 4 1

Purpose of piping	Length, L m	Diameter, D mm	Number of valves	t, °C
1 Steam	42	89	4	130
2 Steam	6	50	-	130
3 Steam	40	219	2	95
4 Hot water	60	150	2	95
5 Hot water	80	89	2	95

The efficiency of the steam boiler is 89% and efficiency of the steam distribution system is 78% according to the operation chart Consumption of steam at the pressure of 10 kg/cm^2 is 5 tons/hour considering that the boiler operates 140 hours a week , 52 weeks a year

It is recommended that the steam and hot water piping should be fully insulated

The thickness of insulation should be selected depending on the piping diameter and its purpose The data are furnished in Table A 4 2

Table A 4 2

Purpose	Diameter, mm	Insulation thickness, mm
1 Steam	50 - 89	80
2 Hot water	219	92
3 Hot water	89 - 150	42

Annual energy savings estimate

We define the thermal energy waste for insulated and non-insulated pipes in accordance with the methodology [Methodological instructions for determination of losses of fuel and energy resources RD5 EDIV 015-008094 Minmashprom, Kiev, 1994]

Thermal energy waste in non-insulated pipes (kcal/hour) is determined by the following formula

$$Q_{nin} = g_{nin} \, x \, L_o \, x \, k \, ,$$

where g_{nin} - specific losses of non-insulated piping (kcal/meter x hour),

k - correction factor which depends on the air temperature and the difference between pipe wall temperature and air temperature,

L_o - given length of piping, m

$L_o = L + (1m \times n)$,

n - number of valves within the section

For the pipeline #1 from Table A 4 1 we have

$Q_{nin1} = 450 \times (42+4) \times 0\ 95 = 19{,}665$ *kcal/hour*

Further calculations were carried out similarly and are summarized in Table A 4 3

Thermal energy waste of insulated (kcal/hour) pipelines are calculated by the formula

$Q_{in} = g_{in} \times (t_1 - t_2) \times a \times b \times L_0$

where g_{in} is specific loss over 1 meter of piping with difference $(t_1 - t_2) = 1^0C$ depending on the thickness of insulation,

t_1 - temperature of pipe walls assumed as equal to temperature of heat carrier, °C,

t_2 - temperature of the air, °C,

a - correction factor depending on the thickness of insulation, thermal conductivity if insulation material and temperature difference between heat carrier and air With insulation thickness up to 100 mm and temperature difference up to 300 °C $a = 1$,

b - wind correction factor (with wind velocity of 5 m/sec)

Presently it is realistic to cut down waste in the thermal networks by using modern efficient types of thermal insulation materials such as cellular plastics, Styrofoam and other with thermal conductivity of 0 03 - 0 05 kcal/ (m x hr x °C) We assume the use of the materials above

For pipeline #1 from Table A 4 1

$Q_{in1} = 0\ 163 \times (130 - 15) \times 1 \times 1\ 03 \times 46 = 888$ *kcal/hr*

Similar calculations were carried out for all pipelines and are shown in Table A 4 3

Net savings are received taking into account the length of a pipeline and full savings - considering the steam distribution system and boiler efficiency

Table A 4 3

Pipeline No	Given length	Thermal waste without insulation	Thermal waste with insulation	Net savings	Full savings
	L_o, m	Q_{nin}, kcal/hr	Q_{in}, kcal/hr	S_N, kcal/hr	S_F, kcal/hr
1	46	19,665	888	18,777	29,357
2	6	1,653	127	1,526	2,386
3	42	43,890	1,260	42,630	66,652
4	62	41,230	2,769	38,461	60,133
5	82	32,718	1,394	31,324	48,974
			Total	**132,718**	**207,502**

Thus annual savings should amount to

$S_a = 207,502$ kcal/hr x 140 hrs x 52 weeks x $10^{-6} = 1,510$ Gcal/year
which is equal to 224 thousand m^3

Annual cost savings estimate

Cost of 1 Gcal - $C_{GC} = US\$15\ 8$

Annual savings

$S_M = S_a x\ C_{GC} = 1,510\ x\ 15\ 8 = US\$23,858$

Implementation cost

Total cost of insulation to be installed -

$C_1 = L_{CON}\ x\ C_{INSC} + L_{ST}\ x\ C_{INSS} = 52\ x\ 8 + 186\ x\ 10\ 5 = US\$2,369$

where L_{CON} = total given length of water pipelines 3-5 from Table A 4 1, in meters,

L_{ST} = total given length of steam pipelines 1 and 2 from Table A 4 1, in meters,

C_{INSC}, C_{INSS} = cost of 1 meter of insulation of hot water pipelines respectively, US$ per meter

Cost of installation - $C_2 = US\$2,500$

Total estimated cost $C_{COM} = C_1 + C_2 = 2,369 + 2,500 = US\$4,869$

Simple payback estimate

Annual savings in costs - $S_M = US\$23,858$

Implementation cost - $C_{COM} = US\$4,869$

Simple payback = $S_M\ /C_{COM} = 4,869/23,858 = 02$ *year* (2 5 months)

A 5 ECO #5 Improvement of combustion efficiency in DKVR-20-13 boiler by excess air control

For thermal energy supply 5 DKVR-20-13 boilers are used (one or two are in operation, the rest are standby) To run these boilers the operation charts have been worked out but automatic control of fuel-to-air ratio in conformity with the load is nonexistent The air consumption value is controlled periodically by the supply air pressure and gas consumption by the pressure before the burners which under the conditions of uncontrolled air infiltration does not allow one to substantiate the idea of optimal combustion processes Control of optimal combustion is carried out by subjective perception of the flame color by the boiler operator

The above mentioned is confirmed by the No 1 and 3 boiler combustion efficiency measurements taken with the ***BACHARACH*** combustion analyzer (Appendix D) As the measurements showed oxygen content in the exhaust pathway of No1 boiler was 7 8-9 6%, No3 - 13 2%, excess air for No1 - 1 54-1 77%, No3 - 1 76-2 56%, exhaust gas temperature after the boiler for No1 boiler - 311^{0}C, at the lowest point of economizer - 152^{0}C, before the exhaust fan - 144^{0}C , for boiler No3 - 236^{0}C, No1 boiler combustion efficiency - 82 9%, No3 - 80 5% (not considering the temperature of input air) Adjustment of supply air pressure at No3 boiler increased combustion efficiency to 84% (measurements 2 and 3, Appendix D) and overall combustion efficiency after economizer to 93 7% (measurement 4, Appendix D)

We recommend to equip the operation personnel of the boiler unit with the ENERAC-2000 or BACHARACH combustion analyzer and to include in the operational responsibilities of the operator periodical check of combustion processes which would ensure the increase of boiler combustion efficiency and savings in natural gas

Energy savings estimate

According to the plant data given in the form No11 MTP "Report on the results of the use of fuel, thermal and electric energy" in 1997 the plant generated 57,731 Gcal of energy while actual fuel use was G=9,237 tce or 7,963,000 cubic meters of natural gas According to the manufacturers certificate the DKVR-20-13 boiler equipped with economizer should have efficiency of η =***92%*** and coal equivalent fuel use of 155 12 kg per 1 Gcal

The measurement results showed that average boiler efficiency was η_{ef} =***82%*** at actual specific consumption of 174,22 kg of coal equivalent per Gcal

Introduction of this measure will reduce the specific use by ~***6%*** and it will reach 162 34 kg per 1 Gcal, average boiler efficiency will rise to ***88***%

Savings of gas in the physical terms will be

$S_G = G \times \Delta b = 7963 \times 0\ 06 = 477\ 8$ thousand cubic meters

Annual cost savings estimate

Money savings at the price of US$ 83 per 1000 cubic meters will be

$S_M = S_G \times 83 = 477\ 8 \times 83 = US\$39,660$

Implementation cost

Cost of ***ENERAC - 2000*** combustion analyzer - C_1=***US$5,000***

Cost of transportation - C_2=***US$1,500***

Total $C_{COM} = C_1 + C_2 = 5000+1500 =$ ***US$6,500***

Simple payback estimate

Annual savings in costs - S_M = ***US$39,660***

Commissioning costs - C_{COM} = ***US$6,500***

Simple payback

$SP = C_{COM}/S_M = 6{,}500/39{,}660 = 0\ 16$ year

A 6 ECO #6 Energy efficient plant lighting

ECO description

The external lighting system of the plant area consists of 82 SKZPR-250 lighting fixtures with DRL - 250 high pressure mercury lamps installed at 9-meter high ferroconcrete lampposts Part of the area adjacent to the production buildings is lighted by conventional 200-watt and 500-watt incandescent lamps The light flow of the DRL-250 lamp is equal to 10,000 lumen and the nominal service life is 2,400 hours

This recommends replacement of DRL -250 high pressure mercury lamps for external lighting of the plant area with the DNaT-100-3 high pressure sodium lamps using existing fixtures and replacing switching appliances with appropriate capacity The sodium lamps of the DNaT -100-3 type manufactured in the city of Poltava have a longer operation life - 6,000 hours with the light flow of 9,000 lumen

Calculation of annual electric power savings

The electric power use of the SKZPR-250 lighting fixtures with DRL - 250 mercury lamps is

$P_{F1} = (P_{L\,1} + P_{SW,\,1})\ x\ cos\phi$

where $P_{L\,1}$ is the capacity of DRL - 250 mercury lamp, W,
$P_{SW\,1} = 54\ 1$ W is capacity of switching appliances,
$cos\phi = 0\ 98$

$P_{F1} = (250+54\ 1)\ x\ 0\ 98 = 298$ Wh $=0\ 298$ kW

Amount of power used by 72 lighting fixtures over 1 year at average 10-hour use is

$P_1 = P_{F1}\ x\ n\ x\ F$

where $n=82$ is the number of lighting fixtures,

$F=10\ x\ 365 = 3{,}650$ hours - annual time of lighting operation
$P_1 = 0\ 298\ x\ 82\ x\ 3{,}650 = 89{,}191$ kWh

The electric power use of the SKZPR-250 lighting fixtures with DNaT -100-3 lamp

$P_{F2} = (P_{L\,2} + P_{SW\text{-}2})cos\phi$

where $P_{L\,2} = 100W$ is the capacity of DNaT - 100-3 lamp,
$P_{SW\,2} = 7$ W is capacity of switching appliances,
$cos\phi = 0\ 98$

$P_{F1} = (100+7)\ x\ 0\ 98 = 105$ W $=0\ 105$ kW

Power used by 82 lighting fixtures over 1 year at average 10-hour use is

$P_1 = P_{F1}\ x\ n\ x\ F = 0\ 105\ x\ 82\ x3{,}650 = 31{,}426\ 5$ kWh

Annual energy savings by using DNaT-100-3 lamps

$S_{E_E} = P_1 - P_2 = 89,191 - 31,426 = 57,764$ kWh

Annual cost savings estimate

Cost savings at the price of electric power of US$0 048 per 1kW

$S_M = S_{E_E} x\ 0\ 048 = 57,764\ x\ 0\ 048 = US\$2,772\ 7$

Implementation costs

Cost of one DNaT -100-13 lamp with appliances - C_2 = US$*30*

Construction and installation costs not included since the work will be carried out by the plant personnel

Implementation cost - $C_i = 30\ x\ 82 = \$2,460$

Simple payback estimate

Annual cost savings - S_M = US$2,772 7

Implementation costs = C_i = US$2,460

Simple payback

$SP = C_i/S_M = 2,460/2,772\ 7 = 0\ 9\ year$

A 7 ECO # 7 Utilization of steam reduction energy for electric power co-generation

ECO description

The heat supply layout of the boiler house is designed for generation of thermal energy as 13 kg/cm^2 steam by the DKVR-20-13 boilers with successive reduction of steam pressure at the pressure reduction plant (PRP) to 5 atm which is rated for handling 60 tons of steam per hour There are two such PRP at the boiler house

Considering the actual boiler house load at the time of the audit we recommend to install parallel to one of the PRP two steam electric generation plants of the PVM-250-EG type to utilize wasted steam pressure energy

The electric generation plants will ensure steam pressure reduction from 7 - 14 atm to 5 atm with following technical and economic indicators

- maximum electric power transmitted to the supply grids of the enterprise is 2 x 250 kW,
- voltage is 380 V,
- frequency is 50 Hz,
- maximum steam use is 2 x 6 3 tons per hour,
- service life before overhaul is 40,000 hours,
- specific steam consumption is 25 2 kg per kWh

Annual electric power savings estimate

In case of the round-the-clock operation of the boiler house the generation plant will work 24 hours a day and 7,140 hours a year

Total amount of generated electricity will be

$$W_g = 2P_g + T_g = 2 \times 175 \times 7{,}140 = 2{,}500{,}000 \text{ kWh}$$

where P_g Is power output of a generator, kW,
T_g is annual operation time, hours

Annual cost savings estimate

Cost savings due to reduction of electric power consumption from the regional utility will be
$S_c = W_g \times C_e = 2{,}500{,}000 \times 0\ 048 = \$120{,}000$ per year

where C_e is the rate for 1 kWh, $/kWh

Besides, the enterprise can reduce the electricity rate by lowering the negotiated maximum demand

Implementation cost

According to the manufacturer's data specific production and installation cost of a single power plant is $250/kW Therefore, total implementation cost will be

$C_i = 2 \times 250\$/kW \times 250 = \$125,000$

Simple payback

Annual cost savings - S_c = $120,000

Implementation cost - C_i = $125,000

Simple payback

$SP = C_i/S_c = 125,000/120,000 = 1\ 04$ years

A 8 ECO # 8 Infrared heating with direct combustion of natural gas

ECO description

The plant uses space heating of air type for the main production building with excessive ventilation The maximum design heat use is 0 272 Gcal/hour By the data of the plant for this purpose 20 2 thousand Gcal of heat is used Since the plant is not operating to full capacity some of the heat is not used rationally as the entire building is heated not just workplaces

We recommend to install infrared systems with direct combustion of natural gas above workplaces in the liming, tanning, staining, drying water treatment workshops The recommended systems have certain benefits over conventional systems

- 30-50% natural gas savings,
- air flow mixing is not required, draughts are reduced, creation of comfortable conditions with constant temperatures lower by 5-10^{0}C,
- fast acquisition of required temperatures by initial heating of equipment, floor and clothing and subsequent heating of air by convection,
- spot heating as required by production needs,
- automatic temperature control including standby heating during days-off and idletime,
- easy to maintain

During the design phase it is necessary to take into account limitations of utilization of recommended heaters at the production lines and in the rooms of the A and B categories and buildings with fire resistance levels IV and V

Annual energy savings estimate

By the plant data (Appendix D) for ventilation and heating purposes in the liming, tanning, staining, drying water treatment workshops in 1997 considering network losses and excluding air and heat curtains Q_{np} = ***15,800*** Gcal of heat and B_1 = ***2,180*** thousand cubic meters of natural gas were used (Table A 8 1)

Table A 8 1

Workshop	Total use, Gcal	Use without heat curtains, Gcal
1 Liming	2,872	1,842
2 Tanning	4,011	3,688
3 Staining	5,116	5,116
4 Finishing	5,202	5,124
Total	**17,200**	**15,800**

We recommend to install with consideration of design parameters of the building

- in the liming workshop – ***30*** high-rate heaters in three rows with thermal capacity of 1 308 Mcal/hour (450 kW),
- in the tanning, planing and staining workshops– ***30*** high-rate heaters in three rows with thermal capacity of 1 308 Mcal/hour (450 kW),

- in the drying workshop – ***30*** high-rate heaters in three rows with thermal capacity of 1 308 Mcal/hour (450 kW),
- in the water treatment workshop – ***20*** high-rate heaters in three rows with thermal capacity of 1 156 Mcal/hour (908 kW)

Total capacity of heaters will be

$$N_H = 5080 \text{ Mcal/hour } (2258 \text{ kW})$$

Maximum hourly consumption of natural gas will be

$$B_{g2} = l \quad b_e + m \quad b_m = 90 \quad 1\ 42 + 20 \quad 5\ 45 = 236\ 8 \text{ m}^3\text{/hour}$$

where ***l, m*** is the number of high- and low-rate heaters, units,

b_e, b_m is hourly consumption of natural gas by high- and low-rate heaters, m^3/hour

Considering standby mode when 30% of regular mode gas is used consumption of natural gas during the heating season will be

$$B_g = B_{g2} \quad (t_1 \quad 119 + k_s \quad t_2 \quad + k_s \quad 24 \quad 46) = 236{,}8 \quad (16 \quad 119 + 0\ 3 \quad 8 + 0\ 3 \quad 24 \quad 46) =$$
$$= 236\ 8 \quad 2237 = 529863\ 7 = 530 \text{ thousand m}^3$$

where t_1, t_2, ***24*** is operation time of the heating system in regular and standby modes on workdays and days-off, hours,

119, 46 is the number of workdays and days-off during the heating season in the Nikolayev region,

k_s is a coefficient of thermal capacity use of the heaters in standby mode

Natural gas savings will be

$$S_g = B_1 - B_g = 2{,}180 - 530 = 1650 \text{ thousand m}^3$$

Annual energy cost estimate

Cost of thermal energy used for air heating of the above workshops is

$$P_{te} = Q_h \quad C_{TE} = 15{,}800 \quad 31\ 61 = 499{,}438 \text{ Hr} = \$249{,}720$$

where C_{TE} is production cost of ***1*** Gcal of heat, Hr

Cost of natural gas used for infrared heating

$$P_{gh} = B_g \quad C_2 = 530 \text{ x } 83 = \$43{,}990$$

where C_2 is the cost of ***1,000*** m^3 of gas, $

Annual cost savings $S_h = P_{TE} - P_{gh} = 249{,}720 - 43{,}990 = \$205{,}730$

Implementation cost

We recommend to utilize high- and low-rate ***Schwank*** heaters using low-pressure natural gas

Equipment cost

$$C_e = l \quad H_{lr} + m \quad H_{hr} = 90 \quad 516 + 20 \quad 1188 = \$70{,}200$$

where H_{lr}, H_{hr} are the costs of high- and low-rate heaters with VAT included, $

Commissioning cost (cost of designing, gas supply, installation) are assumed at $C_c = \$120{,}000$

Total costs

$$C = C_e + C_c = 70{,}200 + 120{,}000 = \$190{,}200$$

Simple payback

Annual energy savings – $S_e = \$205{,}730$

Implementation cost – $C = \$190{,}200$

Simple payback

$$SP = C/S_e = 190{,}200/205{,}730 = 0\ 92\ year$$

A9 ECO # 9 Automatic energy metering system

ECO description

The enterprise uses several types of energy and fuel electric power, gas, steam, compressed air and technical water

Electric power is supplied via the 10 kV cable to two distribution units DU1 and DU2 each with two 10 kV inputs At the plant site power distribution is performed via 15 substations with two t10/0 4 kV transformers each of total capacity of 27 960 kVA (6 x 1,600 kVA, 10 x 1,000 kVA, 12 x 630 kVA, 2 x 400 kVA) Commercial metering is performed at the DU1 and DU2 inputs The readings are taken down manually There is no technical metering

The detailed study showed that calculations of steam, electric power, gas, compressed air, hot and cold water consumption by separate production units of the tannery are made by standard indicators and actual production output figures Instrument metering is non-existent

We recommend to automate commercial and technical metering using the ITEK technical instruments manufactured by the Energiya R & D institute in Kiev These instruments are metrologically certified in Ukraine and are designed for continuous and periodical measurement/registration of physical values

Introduction of the ITEK-X1X allows consumers to pay their electric power bills by the one-rate tariff differentiated according to the daytime zone which in conjunction with the measures of reduction of the maximum hour consumption provides a considerable cost effect that has been proven by more than a single annual operation at numerous Ukrainian facilities

ITEK-210 and ITEK-310 are intended for commercial and technical metering of electric power (differentiated by time) and build-up of automatic metering and control systems of electric power use (AMCSEPU) in combination with electric meters of three-phase induction type equipped with pulse generation devices (E440, E870, UP-1, UP-2, UP-3, SU-500) or electronic (Siemens, Landys and Gyr, Alpha-ABB, etc) with pulse output They support 64 (for ITEK-210) or 12 (for ITEK-310) metering channels, 4 tariff zones, day schedule for all metering channels is a 5 days' minimum, 2 independent data interfaces

ITEK-210 can be used in combination with or instead of the installed TsT-5000 systems by connection to the existing matrix of primary measurement converters The ITEK-210 is included in the State register of measurement devices of Ukraine

The ITEK-410 is designed for 4 metering channels and is similar to the above devices Additionally it supports tariffs differentiated by peak consumption and demand, and provides monitoring and control over consumption process Daily schedules from 4 channels are stored for not less than 1 month

Introduction of ITEK-X2X allows consumers to meter resources with high accuracy and pay the bills for actual consumption but in proportion to the area

ITEK-220 and ITEK-320 are designed for automatic commercial metering and telemetric control of supply and consumption of liquids, gases, steam and thermal energy in combination with any primary measurement converters of consumption, temperature, pressure and pressure drop with

standardized output parameters at supplier's (thermal power plant, district heat, boiler houses) and consumer's sites (industrial enterprises, public utility facilities) The ITEK-X20 devices are designed in conformity with requirements of RD-50-213-80, PR34-70-010-85, State standard 6651-84 and recommendations R75 of the Ministry of health

ITEK-220 and ITEK-320 intended for the facilities of the first metering group (up to 4 facilities) with a complex configuration of supply and recovery piping (ITEK-220), and for the facilities of the first or second metering groups (one facility) (ITEK-320)

In order to implement the ECO it is planned to set up commercial metering of power consumption at 8 points, commercial gas metering at 1 point and of technical water at 2 points

Technological metering of electric power will be implemented at 60 points, hot technical water at 6 points, technical water at 8 points, steam at 11 points, compressed air at 3 points, gas at 5 points, condensate at 1 point

Annual energy savings estimate

Judging from the experience expected savings from introduction of own automatic metering at the plant and energy use planning and control system will be not less than 5%

Therefore, based on the 1997 data annual savings of natural gas will be 405 thousand m^3, of electric power - 1,000 thousand kWh

Annual costs saving estimate

Currently the plant pays for the energy US$1 7 mln Thus the energy savings in money terms will amount to

$S_E = 1,700,000 \times 0\ 05 = US\$85,000$

Implementation costs

Cost of equipment and construction in US$
Commercial metering of electricity, gas, technical water, steam = 40,000
Technical metering of electricity, steam, hot and cold water, compressed air, gas, condensate - = 80,000
Construction and installation costs - = 30,000

Total estimated costs

$C_{est} = = US\$150,000$

Simple payback estimate

Annual savings in costs - S_M = US$85,000
Commissioning costs - C_{COM} = US$150,000
Simple payback

$SP = C_{est}/S_M = 150,000/85,000 = 1\ 8$ *years*

A 10 ECO # 10 Introduction of air curtain blocking while opening gates of the main building

ECO description

The gates of the main building are equipped with a system of hot air curtains to prevent infiltration of cold air inside while the gates are open However, the audit resulted in finding that the above mentioned systems work round the clock during the heating season

We recommend to add to the system of air curtains an automatic blocking feature to be used to turn off ventilation and thermal supply to air heaters while the gates are closed

Annual energy savings estimate

Thermal energy savings will be calculated by the following formula

$$Q_{tc} = T\sum_{i} Q_{tci}(t_{1i} - t_{2i})$$

where T is duration of the heating season, days,

t_{1i}, t_{2i} is the time of operation of an I-curtain without and with automation, hours,

Q_{tci} is heat use per hour for creation of an air curtain, Gcal per hour

Simultaneously, electricity savings will be ensured defined by the following formula

$$W_{tc} = T\sum_{i} P_{tci}(t_{1i} - t_{2i})$$

where P_{tci} is electric motor capacity of an I-curtain, kW

Duration of the heating season (days-off excluded) $T = 120$ ***days***

The results of heat and electricity savings are shown in Table A 10 1

Table A 10 1

Location of air curtain	# of air curtain	Heat use per hour	Fan motor capacity	Time t_{1i} hours	Time t_{i2} hours	Heat savings Gcal/day	Electricity savings kWh/day
1 Liming workshop	VTZ 14	632,600	30 0	24	4	12 66	600
2 Ready product warehouse	VTZ 3 VTZ 4 VTZ 5	201 000 201 000 144 120	7 5 3 0 3 0	8 8 8	2 2 2	1 2 1 2 0 86	45 18 18
3 Tanning workshop	VTZ 16	193 960	10 0	24	2	4 27	220
4 Repair workshop	VTZ 7 VTZ 8	140 280 144 120	7 5 7 5	24 24	2 2	3 08 3 17	165 165
5 Auxiliary materials workshop	VTZ 1 VTZ 2	139 440 147 370	2 2 2 2	8 8	2 2	0 84 0 88	13 2 13 2
Total						**28 16**	**1257 4**

Total heat savings will be $Q_{tc} = 120 \quad 28\ 16 = 3380$ ***Gcal*** (***502,000*** cubic meters of gas)

Total electricity savings will be $W_{tc} = 120 \quad 1257\ 4 = 150\ 9$ thousand kWh

Annual cost savings estimate

Cost savings with price of *1* Gcal of heat will be $*15 8* and 1 kWh of electricity of $*0 048* will be

$$S_q = Q_{tc} \quad 15\ 8 + W_{tc} \quad 48 = 3{,}380 \quad 15\ 8 + 150\ 9 \quad 48 = 60{,}647 \text{ \$ per year}$$

Implementation cost

Cost of materials and electromagnetic valves - $C_p = 5000$ $

Cost of installation is insignificant as it will be carried out by the plant staff

Simple payback

Annual cost savings – $S_a = 60{,}647$ $

Implementation cost – $C_t = 5{,}000$ $

Simple payback

$$SP = C_t / S_a = 5000/60647 = 0\ 08 \text{ year}$$

A 11 ECO # 11 Replacement of single-pane windows in the main building with double-pane

In conformity with the State construction standards the windows of industrial buildings should be double As the audit showed double-pane windows are not completed overall in the main production building In particular, 1,500 m^3 of windows are replaced with double-pane ones with aluminum framing that reduced significantly the heat waste by the increase of the thermal resistance of the shielding and by lowering of the external infiltration However, the tannery has 600 m^2 of single-pane windows and the recommended work should continue Additionally, we recommend to consider replacement of single-pane ceiling windows over certain premises at X-Y axis, particularly, in the sorting and measurement units

Annual cost savings estimate

Annual heat savings due to the replacement of the one-pane windows is defined by the following formulas

$$Q_0 = F \ (k_0 - k_{dp}) \ (t_a - t_{hs}) \ N \ 24$$

where F is the area of the glassing, m^2,

k_0, k_{dp} is a coefficient of thermal conductivity with single and double-pane windows°C),
t_a is the ambient temperature during the heating season, ^{0}C,
N - duration of the heating season, days

For the city of Voznesensk $N = 168$ days, however it should be taken into account that out of them only $N_w = 120$ are workdays (holidays excluded), $N_{do} = 48$ days-off, ambient temperature during the heating season $t_{hs} = +\ 0\ 4$ °C, thermal conductivity coefficient for large-block buildings is $k_o = 5\ 5$ kcal/(m^2 hr °C), $k_{in} = 2\ 7$ kcal/(m^2 hr °C), inside temperature during worktime (t_w) in the liming tanning and staining workshops is– 17 °C, in drying workshop is– 23 °C, in other workshops – 18 °C, the temperature outside worktime is $t_{off} = 5$ °C

In general, for the i-sections of the workshops the calculated formula will be as follows

$$Qo = (k_o - k_{in}) \ 24 \ \sum_i F_i \left[(t_{tp_i} - t_{off}) \ N_w + (t_{off} - t_{hs}) \ Ndo \right]$$

Results of calculations are given in Table A 11 1

Table A 11 1

Workshop	Window area, F_i, M^2	Inside temperature, t_{ini}, °C	Heat use reduction, Gcal
Finishing	600	18	92 4
Sorting and measurement	60	23	11 6
Total	**660**	–	**104**

Annual heat savings – 104 Gcal ($15\ 4$ thousand m^3 of gas)

Annual cost savings estimate

Annual cost savings at the price of *1* Gcal of heat will be *15 8*$

$$S_c = Q_o \quad 15\ 8 = 104 \quad 15\ 8 = 1{,}643 \text{ \$ per year}$$

Implementation costs

Cost of materials and glass – $C_{pur} \approx 6{,}500$\$

Simple payback

Annual cost savings $S_c = 1{,}643$\$

Implementation costs $C_I = 6{,}500$\$

Simple payback

$$SP = C_{pur}/S_c = 6{,}500/1{,}643 = 4\ 0 \text{ years}$$

A 12 ECO # 12 Monitoring of boiler equipment operation and temperature modes of heat-consuming equipment

ECO description

The tannery has an extensive steam and condensate heating system, however, in-built control pressure gauges and thermometers are practically absent It is impossible to perform an analysis of the efficiency of heat-using equipment, to calculate specific consumption and to promptly discover equipment deficiencies

We recommend to introduce at the plant a portable infra-red thermometer of ***"Reynger ST6"*** type that will enable monitoring of the heat consuming equipment and to supervise it regularly (*1 - 2* times a week) the efficiency of its operation and to react promptly to the thermal energy wastes Expected efficiency improvement of the heat use is ***0 3–0 6%***

Annual thermal energy savings estimate

Annual savings – *0 5%*

Annual steam consumption – *57,731* Gcal

Estimated thermal energy savings

57,731 Gcal *0 005* = *288 6* Gcal,

that makes *41 9* thousand m^3 of natural gas

Cost of 1 Gcal of steam – *15 8*$

Cost savings

288 6 Gcal $*15 8* = $*4,560*

Recommended equipment and its cost

The cost of the portable infra-red thermometer of ***"Reynger ST6" type*** – $*1,000*

Simple payback

$*1,000*/$*4,560* = *0 22* year ≈ *3* months

A 13 ECO № 13 Monitoring of electric motor capacities and electric power use

ECO description

Approximately *87%* of total electricity use of the tannery are used for production purposes according to the 1997 data which amounts to *21,278* thousand kWh to the sum of *1,022,000*$

Some of the primary consumers of electric power are electric motor drives of production, pumping and ventilation equipment

Previously in case of motor failures they were replaced with disregard to the nominally required capacity As the measurements at the tanning workshop, compressor room, water pumping stations and at ventilation fans showed the rated capacity of electric motors is used at *30–40%* Even similar equipment uses various capacity motors often exceeding the needs The total rated capacity of 210 motors at the production lines is *1,805* kW

Total capacity of *57* electric motors in the steam power unit and compressor room is *2,818* kW Therefore the rated capacity of the electric motors at the tannery is *4,623* kW Besides, considering that *15* transformer substations have two transformers each but not all of them are used operation supervision of the power factor is difficult

We recommend to institute operation control over the actually used motor capacities (first and foremost, motors of pumps and fans) with the help of portable instrument set of ***Clamp-on Digital Wattmeter*** and ***Power Factor Meter*** The recommended measure will allow monitoring of the actual motor loads, analyze the efficiency and organize replacement with more efficient motors Implementation of this project will save not less than *1,5%* of electric power used for production purposes annually

Annual savings estimate

1 Annual electricity use by 1997 data – *21,278,000* kWh

2 Cost of *1,000* kWh – $*48*

3 Estimated reduction of electricity use – *1 5%*

4 Savings estimate

21,278,000 kWh *0 015* = *319,000* kWh

5 Cost savings

319,000 kWh $*48* = $*15,312*

Recommended equipment and its cost

Cost of a single set of portable instruments of "***2000 A Wattprobe***" and "***Power Factor Meter, TIF 2300***" type considering overheads and contingencies – $*1,000*

Cost of monitoring and efficiency analysis of equipment use – $*5,500*

Total costs – $*6,500*

Simple payback

$*6,500*/$*15,312* = *0,43* year ≈ *5* months

APPENDIX B SPECIFICATIONS FOR THE REQUIRED EQUIPMENT

Specifications of equipment to be delivered to the VOZKO JSC

No of ECO by section 7	Designation	Type, model	Manufacturer, country	Basic parameters	Requirements		Price		Cost of shipment		Note
					Unit	Qty	Hr	$ US	Hr	$ US	
1	2	3	4	5	6	7	8	9	10	11	12
ECO No 1	Non-contact infrared thermometer	Model ***PM3L3SZ***	***"Raytek"***, USA	***t = -20 + + 1000*** °C ***$L_{measure}$ = 10 m***	pcs	1	–	1600	–	1600	
	Electric power/demand analyzer	Model ***DRANETZ***	***"Dranetz Technologies, Inc"***, USA		pcs	1	–	5000		5000	
	Portable anemometer	Model ***444HT***	***"Kurz Instruments, Inc"***, USA		pcs	1	–	1300	–	1300	
	Multimeter	Model ***87***	Firm ***"Fluke Mfg Co, Inc"***, США		pcs	1	–	500	–	500	
	Power factor meter	Model ***382060***	***Davis Instruments*** 4701 Mount Hope Drive Baltimore, MD 21215		pcs	1		599		690	
	Wattmeter	Model ***TIF2000A***	***"TIF Instruments, Inc"***, 9101 N W 7th Avenue Post Office Box 1338 Miami, Florida 33238-9990, США		pcs	1	–	600	–	600	
ВЭС№ 2	Capacitor units	***UKM 62-0,4-144***		***U = 0,4 kV*** ***Q = 14 kVAR***	pcs	8	4560	2580	36480	18240	rated capacity to be specified
	Cosinus capacitor	***КЭ2-0,38-36***		***U = 0,4 kV*** ***Q = 14 kVAR***	pcs	24	240	120	5760	2880	preplanned

Continuation of Table B 1 1

1	2	3	4	5	6	7	8	9	10	11	12
ECO No 3	Float-type steam trap	Model *FT-14*	*"Spirax Sparco Inc"* P O BOX 119 ALLENTOWN, PA	P_y= *16 kg/cm*^{2}, *DN = 20*	pcs	3		455		1365	
	Steam trap	*FT 43-10TV*	*"Spirax Sparco Inc"* P O BOX 119 ALLENTOWN, PA	P_y = *16 kg/cm*^{2}, *DN = 20*	pcs	4		455		1820	
	Condensate strainer	*FIG33*	*"Spirax Sarco Inc"* P O BOX 119 ALLENTOWN, PA	P_y = *16 kg/cm*^{2}, *DN = 20*	pcs	7		110		770	
	Check valve	*DCV2*	Firm *"Spirax Sarco Inc"* P O BOX 119 ALLENTOWN, PA	P_y = *16 kg/cm*^{2}, *DN = 20*	pcs	7		110		770	
ECO No 4	Steam piping insulation	Fiberglass with aluminum coating	USA	*t = 150* °C d_y = *50* mm d_y = *89* mm	m	 6 42	 19,5 19,5	 10,5 10,5	 117 819	 63 441	
	Hot water piping insulation	Foam polyurethane	JSC"Vasilkov refrigeration works" Vasilkov, Kiev region, Sobornaya str 72, Ukraine	*t = 100* °C d_y = *40* mm d_y = *60* mm d_y = *80* mm	m	 219 150 89	 15,9 15,9 15,9	 8 8 8	 3482 2385 1415	 1752 1200 712	
ECO No 5	Combustion analyzer	*ENERAC -2000*	*"Energy Efficiency Systems, Inc"*, 1300 Shames Drive, Westbury, NX 11590, США	*Analysed gases* O_2, *CO*, SO_2, NO_X	pcs	1	–	5000	–	6500	
ECO No 6	High pressure sodium lamp with switching and control equipment	*DNaT-250-3*	JSC Poltava gas discharge lamp works city of Poltava, Zavodskaya str 3, Ukraine	*U = 220* V *P = 100* W	pcs	82	60	30	4920	2460	

Continuation of Table B 1 1

1	2	3	4	5	6	7	8	9	10	11	12
ECO No 7	Steam electricity generator	***PVM-250EG***	Russia	***P = 250 kW*** ***U = 380*** V ***f = 50 Hz*** P_{steam} ***= 7–14*** kg/cm^2	pcs	2	–	62500	–	12500	
ECO No 8	Infrared gas heaters high-intensity low-intensity	 ***JR-50*** ***STS155-60***		 ***P = 15 kW*** ***P = 45 4 kW***	 pcs pcs	 90 20		 516 1188		 46440 23760	
ECO No 9	Energy metering and control set	***ITEK*** (US-made components)	R&D "Energiya+", 252056 city of Kiev, Pobedy blvd 37, bldg 22, Ukraine	Commercial metering Technical metering	pcs pcs	1 1		40000 80000		40000 80000	

APPENDIX C COLLECTED AND MEASURED DATA

Measurement results of combustion efficiency of natural gas in the No1 DKVR - 20 - 13 boiler of the VOZKO boiler room on 03 24 1998

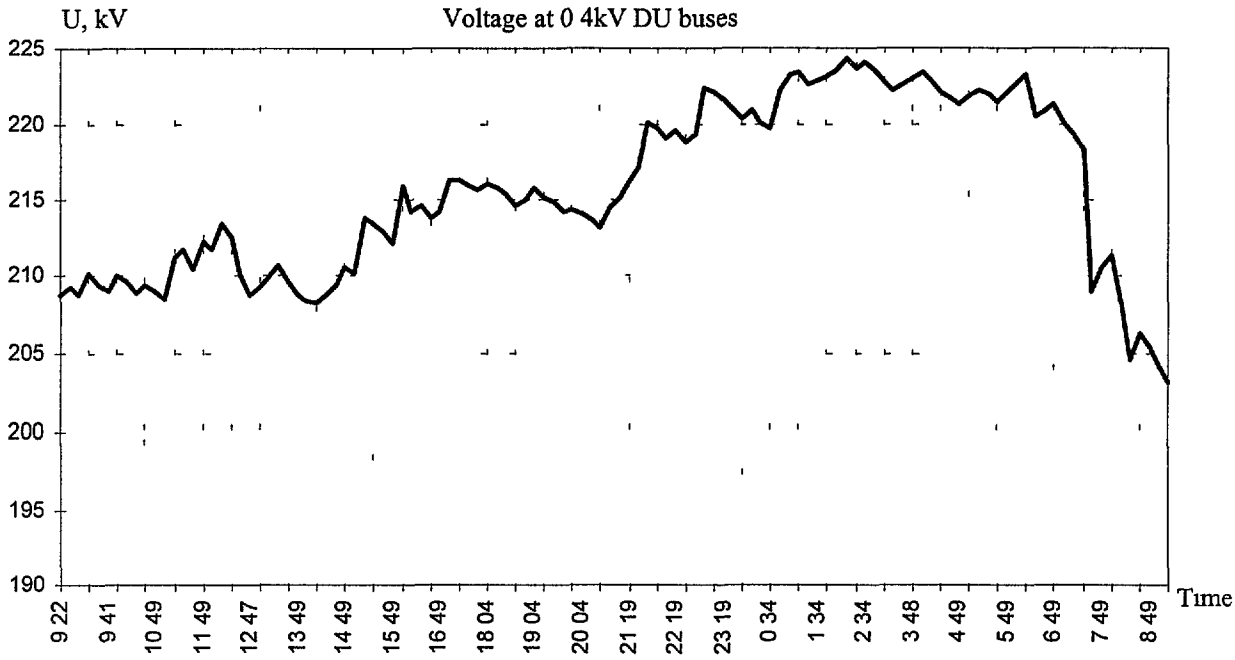
Measurement No1 (after boiler)	Measurement No2 (after boiler)	Measurement No 3 (at the lower point of economizer)	Measurement No 4 (before fan)
BACHARACH MODEL CA300NSX ********** COMBUSTION ANALYZER	BACHARACH MODEL CA300NSX ********** COMBUSTION ANALYZER	BACHARACH MODEL CA300NSX ********** COMBUSTION ANALYZER	BACHARACH MODEL CA300NSX ********** COMBUSTION ANALYZER
ID _____	ID _____	ID _____	ID _____
SER NO VCO 512	SER NO VCO 512	SER NO VCO 512	SER NO VCO 512
TIME 10 09	TIME 10 10	TIME 10 19	TIME 10 38
DATE 24, 03, 98	DATE 24, 03, 98	DATE 24, 03, 98	DATE 24, 03, 98
FUEL NATURAL GAS	FUEL NATURAL GAS	FUEL NATURAL GAS	FUEL NATURAL GAS
PRIMRY TEMP <C> 30	PRIMRY TEMP <C> 30	PRIMRY TEMP <C> 14	PRIMRY TEMP <C> 3
STACK TEMP <C> 311	STACK TEMP <C> 308	STACK TEMP <C> 152	STACK TEMP <C> 144
% OXYGEN 8,3	% OXYGEN 8,3	% OXYGEN 7 8	% OXYGEN 9 6
% EXCESS AIR 60	% EXCESS AIR 60	% EXCESS AIR 54	% EXCESS AIR 77
% CARBON - DIOXIDE 7,1	% CARBON - DIOXIDE 7,1	% CARBON - DIOXIDE 7,3	% CARBON - DIOXIDE 6,3
PPM CARBON - MONOXIDE 2	PPM CARBON - MONOXIDE 2	PPM CARBON - MONOXIDE 3	PPM CARBON - MONOXIDE 3
PPM MOX 75	PPM MOX 75	PPM MOX 77	PPM MOX 67
PPM SULFUR - DIOXIDE 0	PPM SULFUR - DIOXIDE 0	PPM SULFUR - DIOXIDE 0	PPM SULFUR - DIOXIDE 0
% EFFICIENCY 82, 9*	% EFFICIENCY 83, 0*	% EFFICIENCY 92, 0*	% EFFICIENCY 90, 6*
% STACK LOSS 17, 1*	% STACK LOSS 17, 0*	% STACK LOSS 8,0*	% STACK LOSS 9,4*
TEST PERFORMED BY	TEST PERFORMED BY	TEST PERFORMED BY	TEST PERFORMED BY

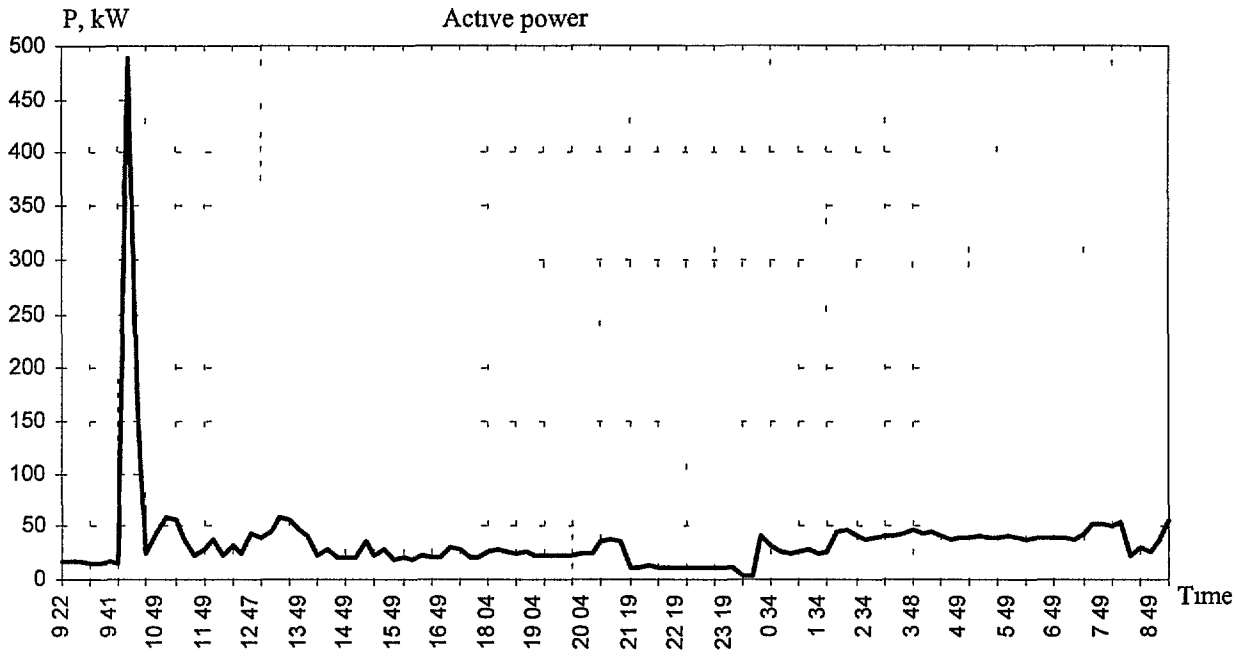
* – without taking account the temperature of input air

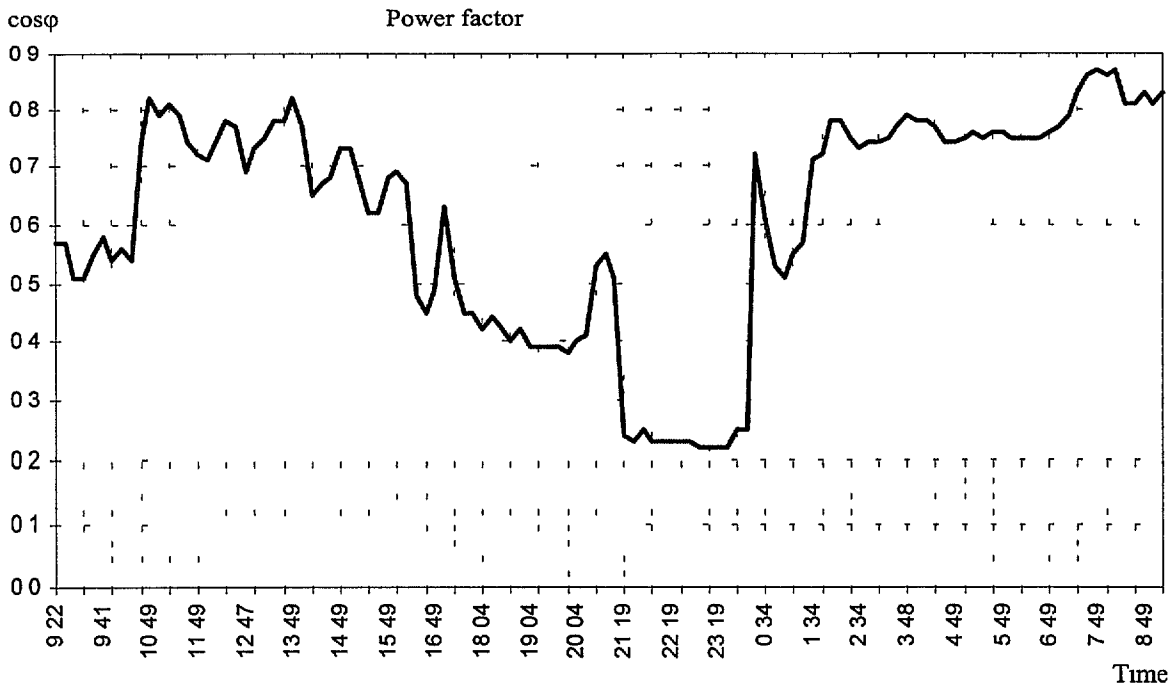
Measurement results of combustion efficiency of natural gas in the No3 DKVR - 20 - 13 boiler of the VOZKO boiler room on 03 24 1998

Measurement No 1 (after boiler)	Measurement No2 (after boiler)	Measurement No 3 (at the lower economizer point)	Measurement No 4 (before fan)
BACHARACH MODEL CA300NSX ********** COMBUSTION ANALYZER	BACHARACH MODEL CA300NSX ********** COMBUSTION ANALYZER	BACHARACH MODEL CA300NSX ********** COMBUSTION ANALYZER	BACHARACH MODEL CA300NSX ********** COMBUSTION ANALYZER
ID _____	ID _____	ID _____	ID _____
SER NO VCO 512	SER NO VCO 512	SER NO VCO 512	SER NO VCO 512
TIME 10 57	TIME 11 07	TIME 11 19	TIME 11 29
DATE 24, 03, 98	DATE 24, 03, 98	DATE 24, 03, 98	DATE 24, 03, 98
FUEL NATURAL GAS	FUEL NATURAL GAS	FUEL NATURAL GAS	FUEL NATURAL GAS
PRIMRY TEMP <C> 28	PRIMRY TEMP <C> 29	PRIMRY TEMP <C> 32	PRIMRY TEMP <C> 17
STACK TEMP <C> 236	STACK TEMP <C> 237	STACK TEMP <C> 235	STACK TEMP <C> 111
% OXYGEN 13,2	% OXYGEN 11,4	% OXYGEN 11,6	% OXYGEN 9,5
% EXCESS AIR 156	% EXCESS AIR 109	% EXCESS AIR 114	% EXCESS AIR 76
% CARBON - DIOXIDE 4,3	% CARBON - DIOXIDE 5,3	% CARBON - DIOXIDE 5,2	% CARBON - DIOXIDE 6,4
PPM CARBON - MONOXIDE 4	PPM CARBON - MONOXIDE 4	PPM CARBON - MONOXIDE 2	PPM CARBON - MONOXIDE 6
PPM MOX 45	PPM MOX 61	PPM MOX 60	PPM MOX 74
PPM SULFUR - DIOXIDE 0	PPM SULFUR - DIOXIDE 0	PPM SULFUR - DIOXIDE 0	PPM SULFUR - DIOXIDE 0
% EFFICIENCY 80,5*	% EFFICIENCY 83,8*	% EFFICIENCY 84,0*	% EFFICIENCY 93,7*
% STACK LOSS 19,5*	% STACK LOSS 16,2*	% STACK LOSS 16,0*	% STACK LOSS 6,3*
TEST PERFORMED BY	TEST PERFORMED BY	TEST PERFORMED BY	TEST PERFORMED BY

* – without taking account the temperature of input air


U, kV
Voltage at 0 4kV DU buses
225
220
215
210
205
200
195
190
9 22
9 41
10 49
11 49
12 47
13 49
14 49
15 49
16 49
18 04
19 04
20 04
21 19
22 19
23 19
0 34
1 34
2 34
3 48
4 49
5 49
6 49
7 49
8 49
Time

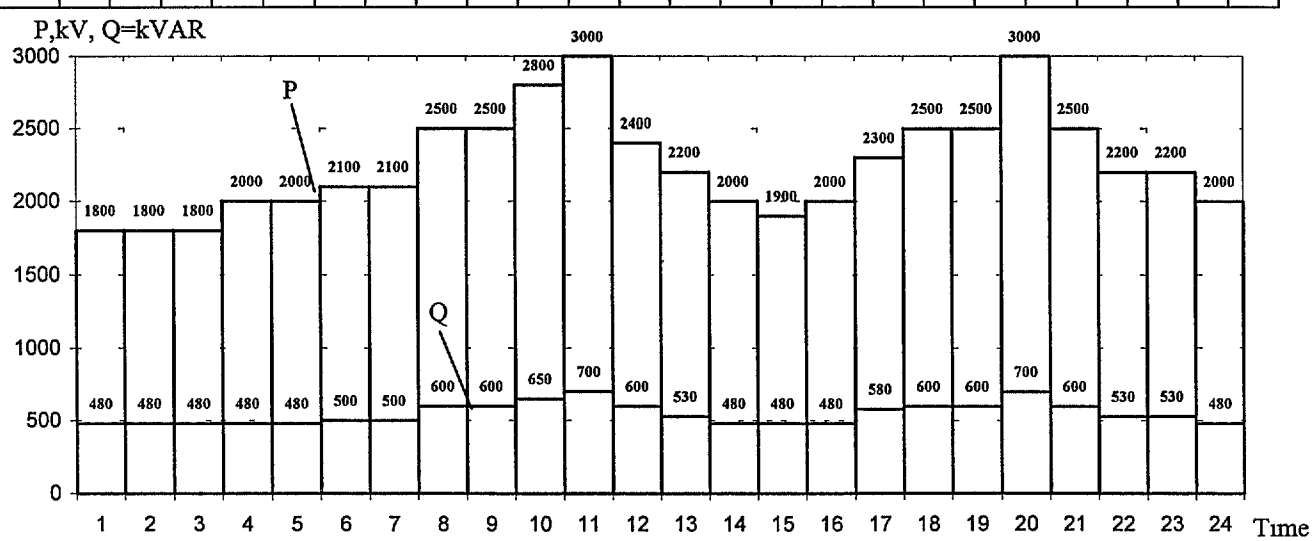

P, kW
Active power
500
450
400
350
300
250
200
150
100
50
0
9 22
9 41
10 49
11 49
12 47
13 49
14 49
15 49
16 49
18 04
19 04
20 04
21 19
22 19
23 19
0 34
1 34
2 34
3 48
4 49
5 49
6 49
7 49
8 49
Time



Results of electric load mesurements of the drum unit of the tanning workshop

Electricity load measurements on June 25 1997

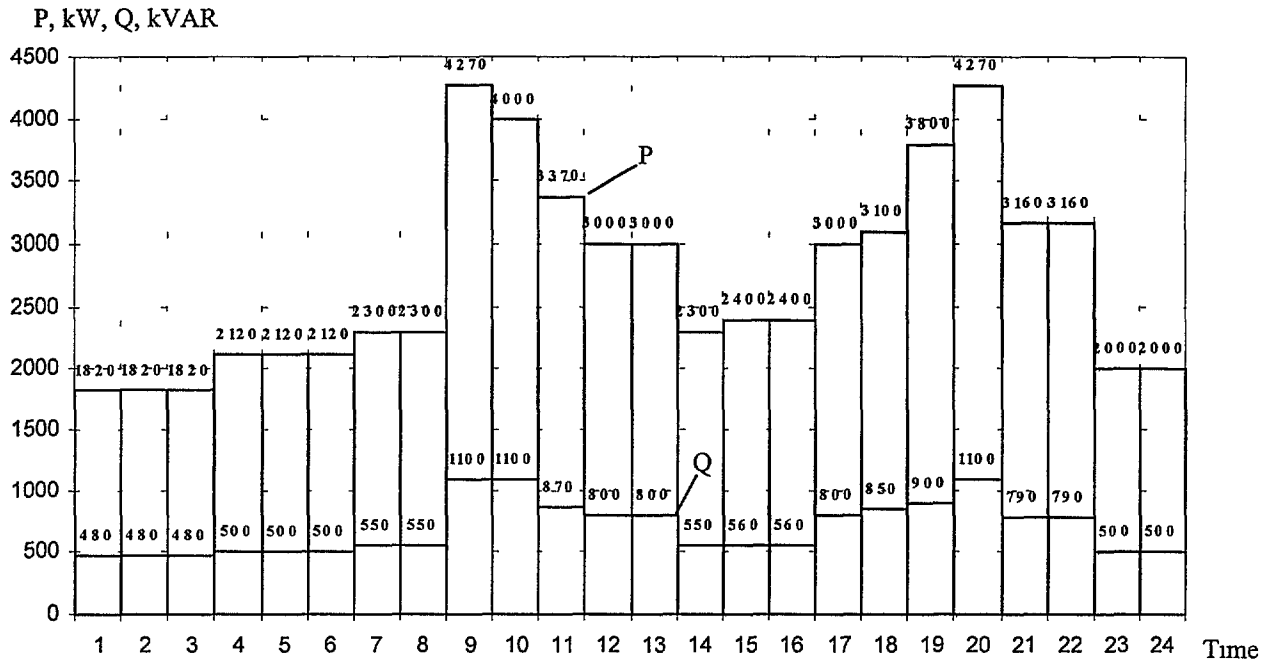
Hours of day	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
P kW	1800	1800	1800	2000	2000	2100	2100	2500	2500	2800	3000	2400	2200	2000	1900	2000	2300	2500	2500	3000	2500	2200	2200	2000
Q, kVAR	480	480	480	480	480	500	500	600	600	650	700	600	530	480	480	480	580	600	600	700	600	530	530	480



The VOZKO load chart on June 25 1997 г (rated capacity – 19,380 kW, maximum load at peak hours – ***3,000*** kW, A_{day} = ***52 1*** kWh, ***Q*** = ***700*** kVAR, ***cos***φ = ***0 703***)

Electricity load measurements on December 17 1997

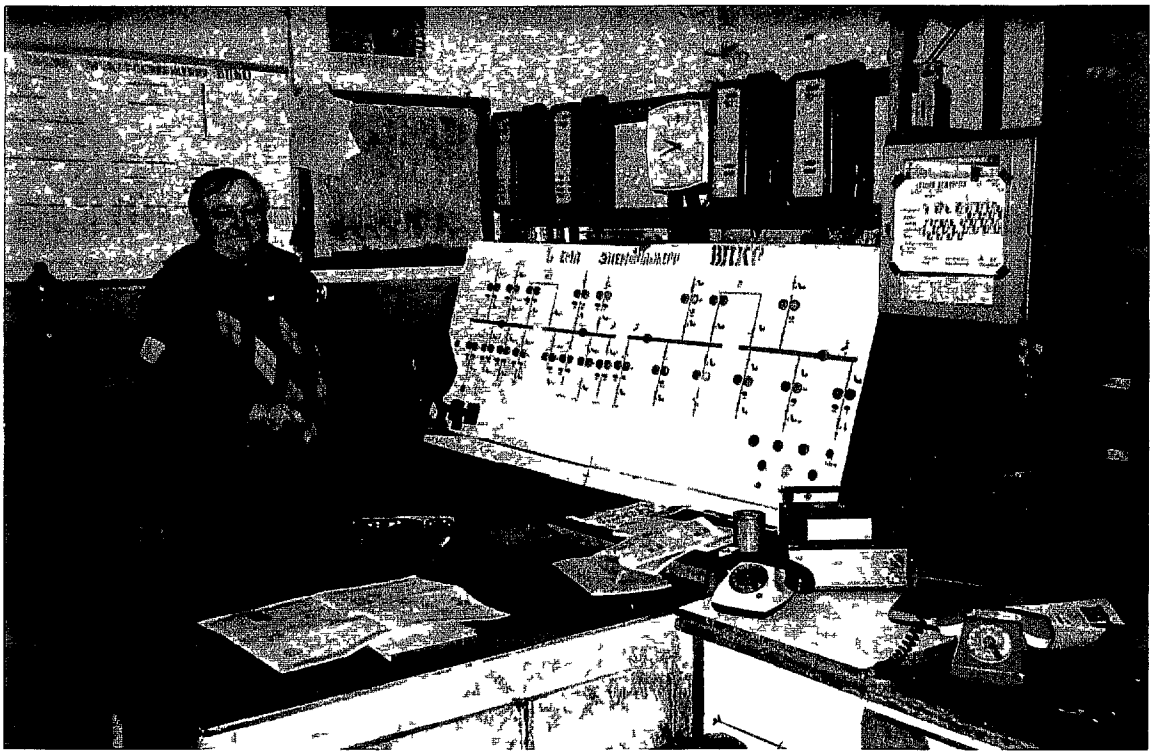
Time of day	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
P kW	1820	1820	1820	2120	2120	2120	2300	2300	4270	4000	3370	3000	3000	2300	2400	2400	3000	3100	3800	4270	3160	3160	2000	2000
Q kVAR	480	480	480	500	500	500	550	550	1100	1100	870	800	800	550	560	560	800	850	900	1100	790	790	500	500



The VOZKO load chart on December 17, 1997 (rated capacity – ***19380*** kW, maximum load at the peak hour – ***4270*** kW, A_{day} = ***63,53*** kWh, ***Q = 1100*** kVAR, ***cos*φ = *0 62***)

APPENDIX D PHOTOGRAPHS OF THE PLANT

Административный корпус
Office building



Диспетчерский пункт энергослужбы предприятия
Dispatcher room of the tannery power supply service

Прямые потери пара на очистных сооружениях завода
Directr steam losses at the wastewater treatment facilities

Измерение параметров уходящих газов котла с помощью газоанализатора Bacharach
Measuring exhaust gas parameters by Bacharach combustion analyzer

Состояние оконных проемов производственного корпуса
Condition of window opening of the main production building

Измерение температуры поверхностей неизолированных трубопроводов
Measuring temperatures of non-insulated piping

Состояние термоизоляции
Condition of thermal insulation

APPENDIX E ABBREVIATIONS AND MEASUREMENT UNITS

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)

ABBREVIATIONS

CIS - Commonwealth of Independent States
ECO - energy conservation opportunity
ESCO - energy service company
etc - et cetera
Hr - hrivnia
i d - id est
JSC - joint-stock company
mln - million
TACIS - Technical Assistance to CIS countries
tel - telephone
thou - thousand
US - United States
USAID - United States Agency of International Development
TP - Distribution unit (DU)
PRP - pressure reduction plant
DU - distribution unit

UNITS OF MEASUREMENT

BTU - British thermal unit
^{0}C - degrees Celsius
cm^2 - centimeter squared
^{0}F - degrees Fahrenheit
g - gram
Gcal - gigacalory
GJ - gigajoule
h - hour
kcal - kilocalory
kg - kilogram

kgf - kilogram-force
kV - kilovolt
kVA - kilovolt-ampere
kW - kilowatt
kW h - kilowatt hour
Lm - lumen
m - meter
m^2 - meter squared
m^3 - meter cubed
min - minute
MJ - megajoule
mm H_2O (of wc) - millimeters of the water column
MW - megawatt
t - tonne
tonne of coal equivalent
t/h - tonnes per hour
W - watt