PN-ACD-554
99371

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

REPORT

ON ENERGY AUDIT

AT OPEN-TYPE JOINT STOCK COMPANY

BELKOZIN

City of Pryluky, UKRAINE

Prepared by Mikhail Tarnovsky
Yuri Bykov
Nelly Smirnova

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

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1 0 EXECUTIVE SUMMARY

1 1 Introduction

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

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

The current report describes the findings of the energy efficiency audit performed by Burns and Roe at the JSC BELKOZIN in the city of Priluky The BELKOZIN plant is the only plant in Ukraine for production of fibrous sausage casing from cattle skin for cooked and smoked/cooked sausages The plant is equipped with production lines for molding of various size sausage casing, casing rewinding and packing
The plant products are in demand at the domestic market, CIS and foreign countries It meets the highest quality standards The sales of fibrous casing in 1997 amounted to US$9,950,000 and the share of exports in the total volume of sales was 69 8% The share of energy in the production cost was 18%

The tasks of the energy audit were as follows

- to conduct informal training in the energy management practices
- to create an institutional awareness of energy management
- to recommend specific steps in order to improve energy efficiency including management actions, low-cost/no-cost opportunities and energy saving equipment that may be procured with the USAID funds
- to recommend medium-cost and capital investment actions reflecting large-scale energy conservation opportunities

The energy audit team made up of three Ukrainian specialists performed the energy audit April 13 through 18, 1998 In compliance with the objectives of the Project the energy audit team prepared the following preliminary report

1 2 Brief survey

The BELKOZIN is an energy-intensive enterprise Consumption of energy in 1997 was as follows
1 Electric power - 11,100,000 kWh
2 Casinghead gas- 6,620,000 m^3

The energy audit team has discovered many attractive opportunities of improving energy efficiency at the current energy and fuel prices Presently the energy efficiency improvement is cost effective though difficult to implement due to high interest rate of the bank credit and general economic difficulties

The BELKOZIN plant is considered fairly successful by Ukrainian standards and is capable of implementing energy savings measures

The rated electric capacity of the plant is 8,430 kVA Average demand varies between 1,500 and 1,700 kW, peak demand reaches 2,100 - 2,300 kW that is 25% of the rated capacity and causes significant waste while operating the transformers under capacities

The rated capacity of the boiler house exceeds the use by 700%

The primary fuel is casinghead gas characterized by varying calorific value that lowers the efficiency of combustion because of the burner control system

The existing energy metering system does not provide adequate information for efficient energy use

The project envisages further implementation of long-term measures by the plants themselves in consort with private Ukrainian energy servicing companies One of the main tasks of ESCO is the possibility of acquiring long-term (for 2-3 years) financing for implementation of energy conservation measures at the enterprises

The energy audit team saw a realistic opportunity to render considerable assistance in energy use reduction by institution of energy management service at the plant by a contract with an ESCO company after completion of the USAID project

Introduction of measures proposed in this project will reduce energy consumption and respective costs by 30%

The time limits of the present Project do not permit the monitoring of the operation of the equipment intended for space heating season

1 3 Recommendations

Recommendations listed below will improve energy efficiency of the plant and reduce the energy costs

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

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 energy saving systems

Generally the energy management section should consist as a minimum of three persons technical supervisor, electrical and thermal engineers The supervisor should be a part of the plant management and report directly to the plant general manager It is essential that energy consumption and energy costs acquire a special importance and a plant manager should be aware of energy conservation potential

The major part of the proposed measures can be implemented with minor adjustments for conditions at other industrial plants i e to be the standard solution of a common problem

If implemented the measures proposed by the auditors will ensure an opportunity to reduce energy consumption annually

- electric power by - 6,720,000 kWh (60%)
- casinghead gas by - 2,743,000 m3 (41%)

and will result additionally in reduction of pollutant emissions

1 Solid particles - 29 6 tons/year
2 Sulfur dioxide - 66 5 tons/year
3 Carbon oxide - 28 3 tons/year
4 Nitrogen oxide - 23 4 tons/year

The recommendations listed in Table 1 will improve energy efficiency of the plant, cut down costs and consolidate the competitiveness of the plant Table 1 lists several energy conservation opportunities with short payback periods

Capital investments of $565,540 into the improvement of energy efficiency (ECO#1 through ECO#11) will result in annual savings of $570,260 later

ENERGY CONSERVATION OPPORTUNITIES

Table 1

	Description	Electric power, 1000 kWh	Casinghead gas, 1000 m^3	Annual savings, $	Project cost, $	Payback, years
1	**Institution of energy management** This ECO will ensure energy use management and reduce energy costs by 10%	1110	662	103'080	51'540	0,5
2	**Introduction of integrated energy metering system** This ECO will monitor on-line energy consumption, prevent excessive energy use and improve energy efficiency at the enterprise	550	330	51'000	70'000	1,4
3	**Optimization of thermal and hydraulic parameters of thermal networks** This ECO is proposed for reduction of unjustified heat losses that entails optimization of space heating systems		324	29'800	18'000	0,6
4	**Thermal energy and electric power cogeneration** This ECO will reduce the share of energy cost in total production cost by replacement of reduction units with two PVM-250 machines for heat and electric power co-generation	3'960		135'000	180'000	1,3
5	**Optimization of combustion control in DKVR-20-13 boilers** This ECO will ensure combustion control by actual air consumption and automatic control of fuel-to-air ratio in accordance with boiler load		330	30'000	32'500	1,1
6	**Thermal insulation of surfaces with temperatures over 60^{0}C** This ECO will significantly reduce heat losses depending on the area and temperature of non-insulated surfaces and reduce energy costs		25	2'300	1'200	0,5

	Description	Electric power, 1000 kWh	Casinghead gas, 1000 m^3	Annual savings, $	Project cost, $	Payback, years
7	**Utilization of DKVR-20-13 blowdown heat and water** This ECO will save water and heat currently drained into sewer It is sufficient to channel blowdown water to deaerator tank for make-up water for heating network		122	11'800	8'000	0,7
8	**Optimization of plant electric power supply** By rearrangement of power transformers in accordance with actual loads, reswitching of power cabling this ECO will reduce the number of operational transformers	390		15'000	12'000	0,8
9	**Optimization of the used technological air heat** Introduction of rust-resistant heat exchangers on the heat piping for air-to-air working media will reduce thermal energy consumption by drying lines by 20-30%		950	90'000	100'000	1,1
10	**Optimization of compressed air system** Replacement of the existing compressor station with compact modular automatic compressor units installed closely to compressed air consumption sites will reduce electricity consumption by 50%, and cut down compressor operation and maintenance costs by 50% as well	650		100'000	91'300	0,9
11	**Reduction of energy use in refrigeration equipment operation** Installation at the cold room entrances of plastic air curtains will reduce refrigeration consumption and, respectively, electricity for its generation	60		2'280	1'000	0,4
	TOTAL	6'720	2'743	570'560	565'540	1

2 0 GENERAL BACKGROUND

General director — Vladimir N Marzhan
Chief energy engineer — Ivan A Maksyuta
Tel (04637) 3-22-93, 5-22-95
Fax (04637) 5-01-80
44, Druzhby Narodov str
Priluky UKRAINE 251350

2 1 Enterprise history

The open joint-stock company BELKOZIN is the only plant in Ukraine for production of fibrous sausage casing from cattle skin collagen for sausages and frankfurters

OJSC BELKOZIN was established by way of reorganization at the decision of the plant workforce of the BELKOZIN plant and was registered on January 25 1994 by the resolution of the district executive committee of the city of Priluky

The plant was built by the joint Soviet-Czechoslovak project and commissioned on 01 01 1981 The design capacity of the plant is 154 million meters of casing a year The maximum output was reached in 1993 and was 177 million meters It was planned to use the design capacity in 1998 to 96%

The main production lines include
- No 1 collagen mass workshop
- No 2 workshop for fibrous sausage casing molding, rewinding, packing and delivery for warehousing

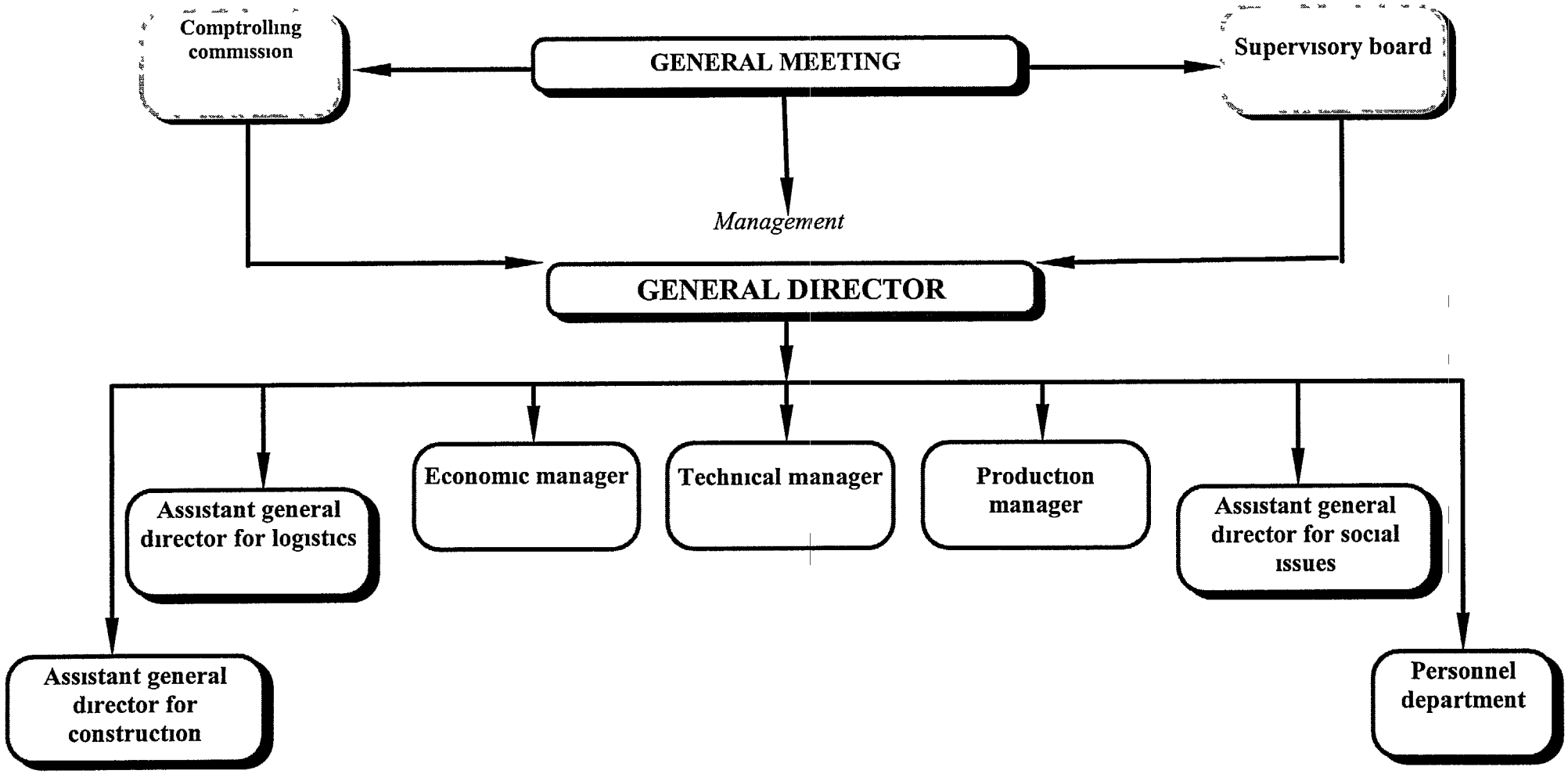
Auxiliary units include
- repair and mechanical workshop
- boiler house
- thermal supply and plumbing unit
- compressor unit
- transportation unit
- electric supply and instrumentation unit

Among the units that inefficiently use the energy the main production workshops can be pointed out The most energy-intensive units are molding and drying lines and refrigeration plants These units operate round-the-clock five days a week The equipment varies in age, a large part is old and should be updated though it is still operating Wear-out of the fixed assets reached 50% as of 01 01 98

2 2 Number of personnel

The casing production process is uninterruptable so the main production lines operate 24 hours a day in three shifts Total plant personnel of the plant is 649 including
- main production personnel - 639
- auxiliary personnel - 10

Organisational structure of management of OJSC BELKOZIN



2 3 Number of similar enterprises in Ukraine

The BELKOZIN plant is the only plant in Ukraine for production of fibrous sausage casing The plant is making profit, provides jobs and exports its products in support of the national economy

2 4 Significance of this sector for national economy

The plant's products are in demand both at the domestic market and in the CIS and abroad The products meet the highest quality standards The fibrous sausage casing is purchased by enterprises producing sausages and smoked meats

Currently, with the buyers' demand at 34 million meters a month the plant produces on average 11-14 mln meters of casing a month

The plant is making a profit, provides jobs and exports products to support the economy,

3 0 CURRENT STATUS OF PRODUCTION

3 1 Production output

The BELKOZIN specialises in production of fibrous sausage casing of 28 to 58 mm diameter and frankfurter casing of 28 to 58 mm diameter Artificial casing is produced either shirred or non-shirred

The analysis of production output in 1995-1997

##	Description	Measure	1995	1996	1997
1	Fibrous sausage casing	million linear m	105 7	106 4	126,4
2	Output at current prices	1,000 Hr	16,083	17,690	18,410

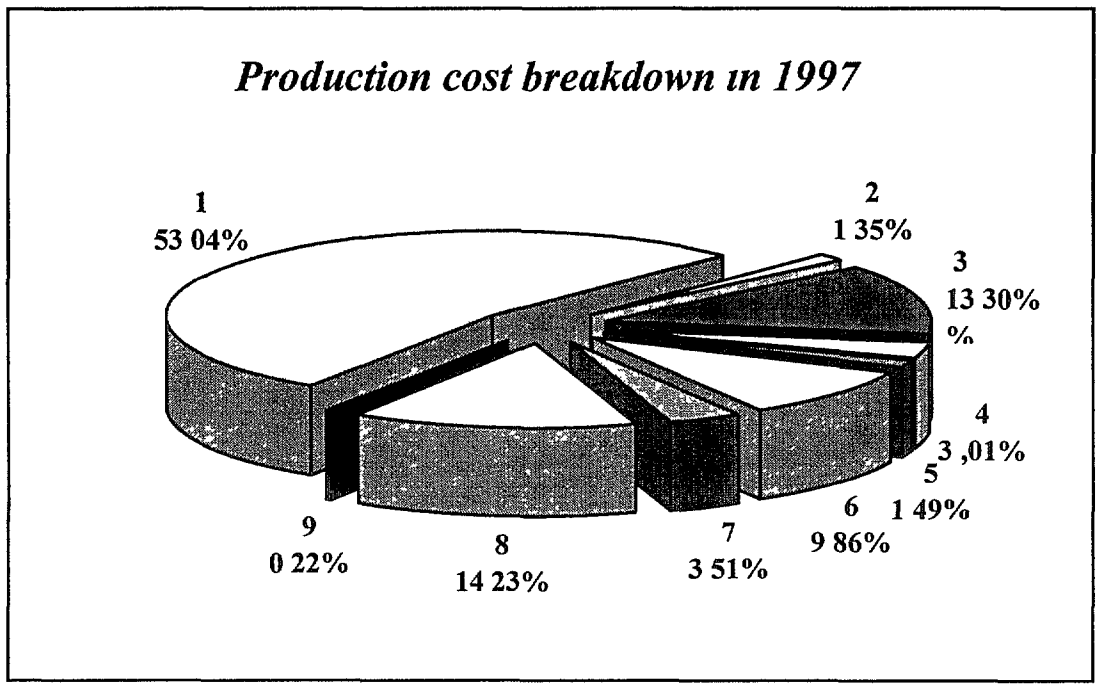
The analysis of the table data show the trend towards the growth of output in the 1995 to 1997 period Estimated output in 1998 should exceed the 1995-1997 outputs by 50%

Calculation of production cost in 1997

##	Name	Costs, 1,000 Hr	Share in total cost, %
1	Raw materials (except turnover funds)	7,562	53 04
2	Transportation and purchasing	193	1 35
3	Production energy costs	1,895	13 3
4	Primary wages	429	3 01
5	Social security deductions	212	1 49
6	Equipment maintenance and operation costs	1,405	9 86
7	General production costs	500	3 51
8	General logistical costs	2,028	14 22
9	Production cost	14,224	99 78
10	Extra production costs	32	0 22
11	TOTAL production cost	14,256	100

3 2 Productivity of labor 1997 vs 1996

#	Description	Unit	1996	1997	1997 vs 1996, %
1	Output at comparable prices	1,000 Hr	17,690	18,410	104
2	Average number of production personnel	persons	702	670	95 4
3	Productivity of labor		25,200	27,480	109



The productivity of labor in 1997 vs 1998 grew by 9%

3 3 Prospects of development

The 1998 plan envisages attainment of production and sales of 147 8 mln linear meters of fibrous sausage casing In money terms the output at current prices will be equal to 22 4 mln Hr , 120% more than in 1997

For the sales the BELKOZIN has established dealerships Both domestic and foreign companies are the dealers

Additionally, a share of products is sold directly to sausage makers Long-term contracts are concluded with permanent customers The foremost competitor at the domestic market is the Bialka of Poland, at the neighboring markets these are the Luga BELKOZIN factory (Russia) and Kutizine company (Czechia)

Using their own funds in 1998 the plant plans to commission a new production line which will provide printing on the casing This will improve attractiveness of the fibrous sausage casing and expand the types of output

3 4 Exports vs Domestic sales

Shares of domestic and export sales

#	Description	Unit	1995	1996	1997
1	Share in total sales in Ukraine	mln meters, %	48 3 45 7	39 6 37 2	38,2 30,2
2	Share in total sales for export	mln meters, %	57 4 54 3	66 8 62 8	88 2 69 8

Currently 70% of the output goes to the CIS countries and abroad

Primary customers of fibrous sausage casing among foreign customers

#	Countries	1995	1996	1997
		millions of meters		
1	Russia	33 5	50 7	58 5
2	Belarus	6 6	1 1	2 8
3	Latvia	5 5	4 5	3 8
4	Moldova	1 5	0 9	0 4
5	other CIS	2	1 5	7 9
6	Romania	7 6	6 9	13
7	Bulgaria	0 3	0 7	0 4
8	Slovakia	0 1	0 5	-
9	Austria	-	-	0 1
10	Poland	-	-	1 3
	TOTAL	57 4	66 8	88 2

4 0 FINANCIAL STATUS OF ENTERPRISE

4 1 Currency vs Barter

All deliveries within the CIS and abroad are made only on payments in the currency of any country under properly concluded contracts with a foreign customer or supplier All currency operations are carried out via bank accounts Given difficult economic situation of numerous enterprises the BELKOZIN is forced to go in for bartering in exchange for necessary services and materials within the country Bartering makes up 6 6% out of total sales In the table below it is shown how the operations in hard currency changed vs barter over the last three years

Currency vs barter in thousand Hr 1995-1997

	Item	Unit of measurement	1995	1996	1997
1	Sales in money terms	thousand hrivnas	16,083	17,690	18,410
2	including barter	thousand hrivnas	4,409	3,383	1 217
3	Percentage by barter	%	27,4	19 1	6 6

4 2 Viability of the enterprise

The complex economic situation in the country has a negative impact on the domestic raw material suppliers whose deliveries declined to 8 5% in 1997 Due to this it has become expedient to establish contacts with foreign suppliers though the quality of their raw materials is lower than that of Ukrainian suppliers The main supplier currently is the Ziegl company of Austria Long-term contracts have been made with all suppliers

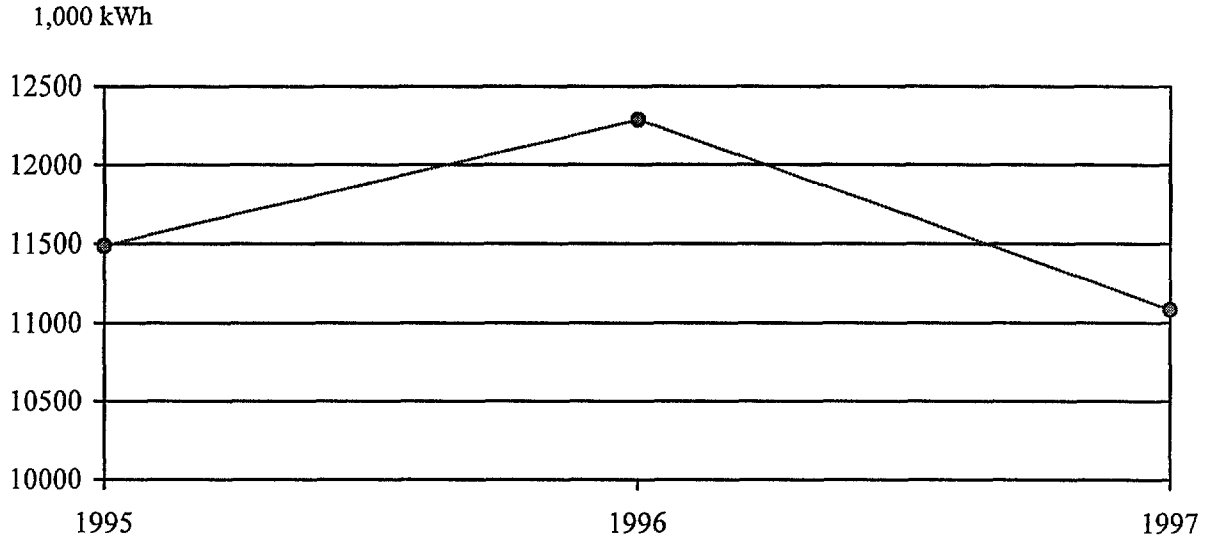
#	Supplier of raw materials	Share in total volume, %	
		1996	1997
1	Ukraine	23 2	8 5
2	Russia	4 5	0 5
3	Belarus	0 5	0 8
4	Lithuania	4 2	10 8
5	Austria	67 6	75 5
6	Germany	-	3 5
7	Italy	-	0 4

Profitability of the OJSC BELKOZIN IN 1997 WAS 18 9%
Receivables - 2,971 7 thousand hrivnas
Payables - 823 9 thousand hrivnas
The share of fuel and energy in the production cost was 18%

5 0 ANNUAL ENERGY CONSUMPTION AND COSTS

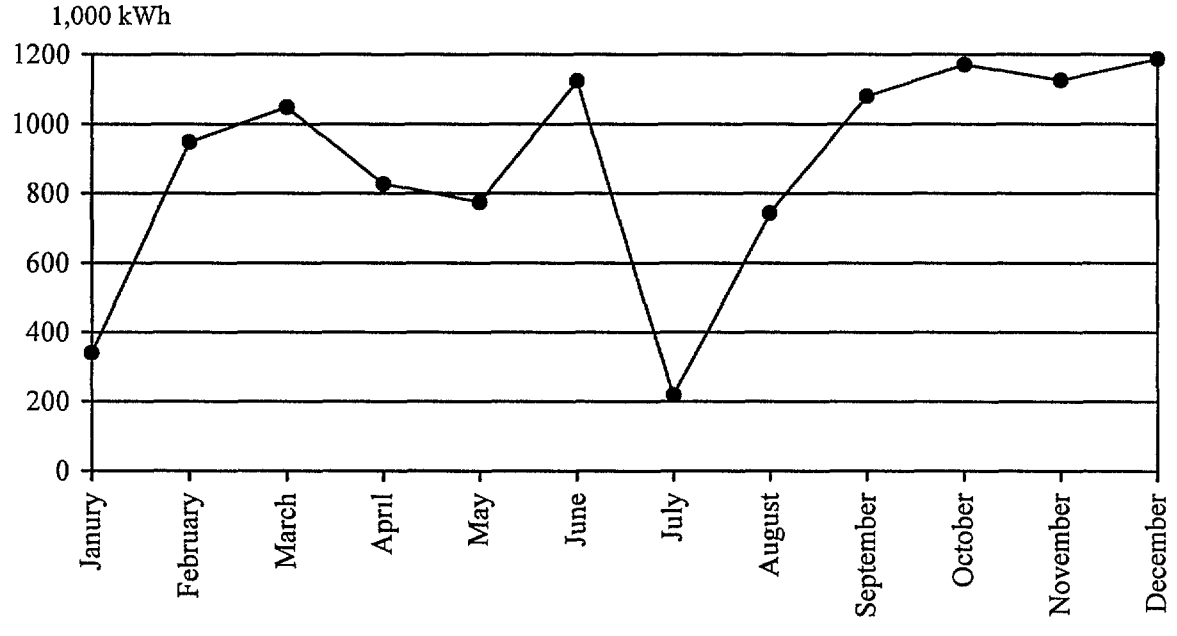
5 1 Annual energy consumption in 1997

Electricity consumption in 1995 - 1997



The 1997 decrease of electricity consumption was due to reduction of refrigeration demand and electricity use for its refrigeration

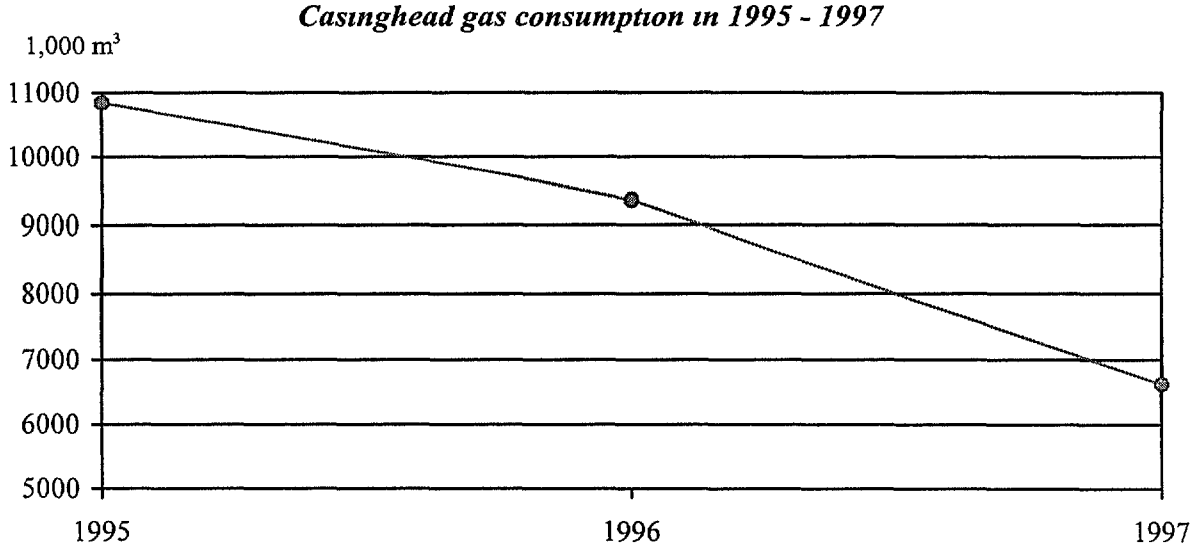
Electricity consumption in 1997



Electricity consumption depends on the production output In January and July the plant performs regular overhaul of the production equipment that results in reduction of electricity consumption

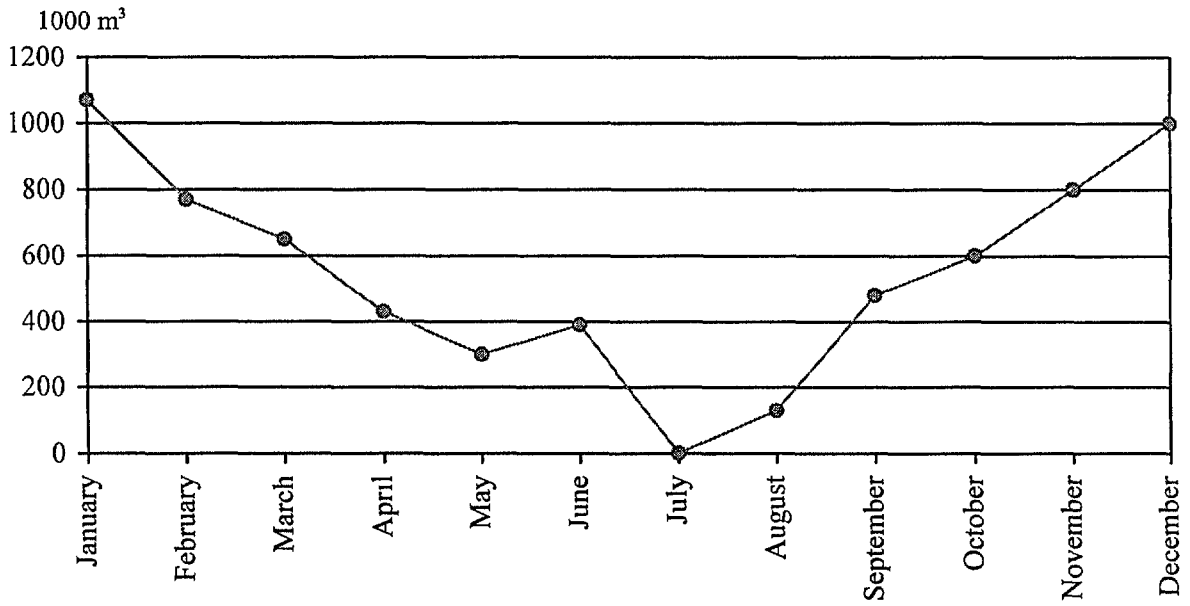
One of the main tasks of the plant is reduction of electricity use during the overhauls and vacation periods At this time the most energy intensive unit is the compressor room Institution of energy management will ensure optimization of the air compressor room operation that will result in reduced electricity consumption during overhaul periods

Casinghead gas consumption in 1995 - 1997



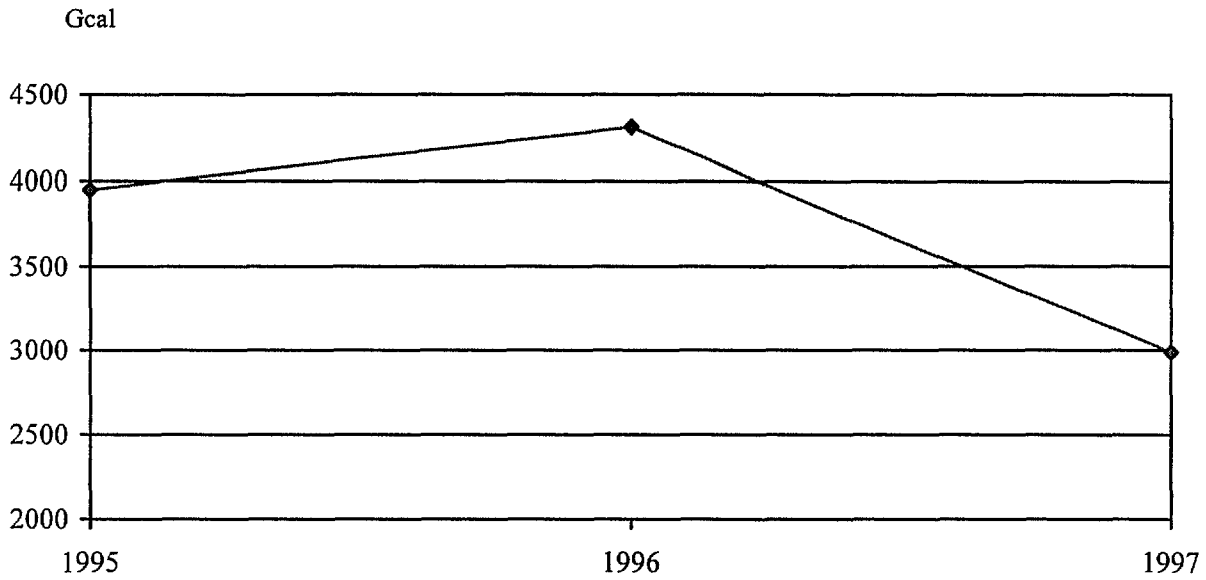
The sole consumer of the casinghead gas is the plant boiler room Reduction of casinghead gas consumption is due to decrease of thermal energy consumption by outside customers

Casinghead gas consumption in 1997



As seen from the chart in July and August the plant was under regular overhaul, during the rest of the months gas consumption should be viewed and analyzed considering constantly changing calorific value of the fuel Gas consumption depends on the production output of the BELKOZIN and outside customers This confirms the necessity for institution of energy management

Refrigeration consumption in 1995 - 1997



The decrease of refrigeration demand in 1997 may be explained by reduction of working time in the summer season and improvement of refrigeration equipment operation With continuous energy management we may forecast the optimal time and periods of idling the plant for capital overhauls This will reduce energy consumption for refrigeration

Energy consumption and costs in 1997

#	Type of energy	Unit of measure	Consumption	Cost, 1,000 Hr
1	Electric power	1,000 kWh	11,000	793
2	Casinghead gas	1,000 m^3	6,620	1,197
	TOTAL			1,990

5 2 Current fuel and energy tariffs

Electricity

The plant pays its electricity bills by two-part tariffs
1 Negotiated demand
2 Amount of consumed electricity by electric meter readings

The contract for electric power supply was concluded by the BELKOZIN at the following prices

- 1 kW of negotiated demand 3 6$

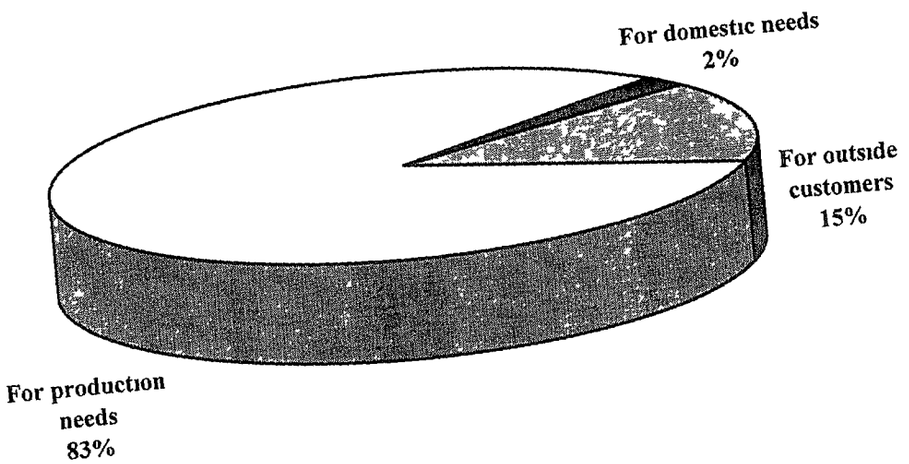
• 1 kWh of consumed electricity	0 031$
Negotiated demand	2,100 kW
Payment for negotiated demand	2,100 × 3 6 = 7,560 ($)
Average monthly electricity consumption	1,100,000 kWh
Payment for actual electricity consumption	1,100,000 × 0 031 = 34,100 ($)
Total payments	7,560 + 34,100 = 41,600 ($)
Actual price for 1 kWh	41,600 / 1,100,000 = 0 038 ($)

Fuel

The only type of fuel used by the BELKOZIN is casinghead gas
The cost of 1000 m^3 of blast-furnace gas – 92$

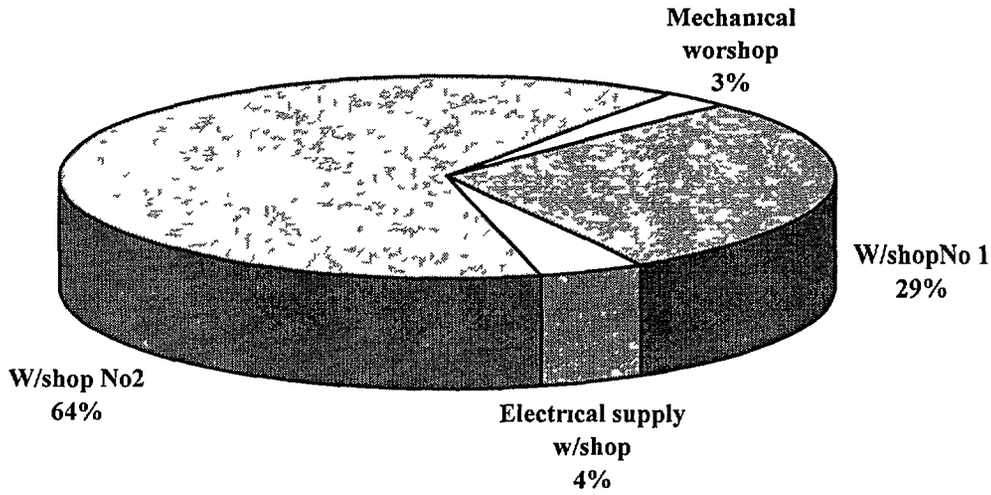
5 3 Energy use profile

Cold water consumption in 1997



#	Cold water consumption	m^3	%
1	By BELKOZIN TOTAL	732,238	85
	• for production needs	713,729	83
	• for domestic needs	18,509	2
2	For outside customers	126,894	15
	SUM TOTAL	859,132	100

Compressed air consumption in 1997



#	Compressed air consumption	1,000 m³	%
1	Workshop No 1	2969	29
2	Workshop No 2	6445	64
3	Mechanical repair workshop	283	3
4	Electrical supply and instrument workshop	444	4
	TOTAL	10,141	100

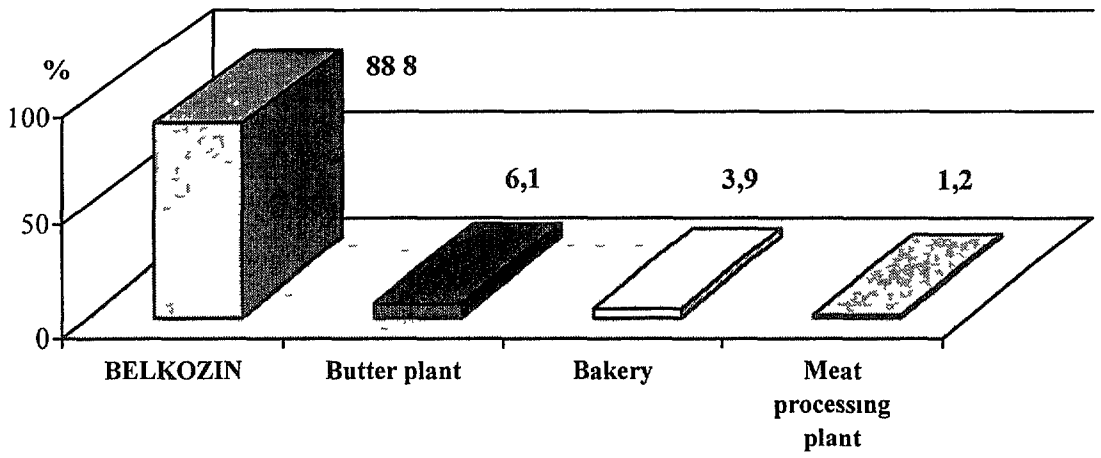
The air compressor station consists of three SK-240 B1 compressors manufactured by CKD - Prague and two VP-20/8 compressors manufactured in Krasnodar, Russia

Total demand for compressed air for production purposes does not exceed 20 m^3/min

Compressed air is usually supplied by two compressors
1 SK-240 B1 with capacity of 16 m^3/min equipped with 100 kW drive motor
2 VP-20/8 with capacity of 20 m^3/min equipped with 132 kW drive motor

Given the wear of the compressors total capacity does not exceed 30 m^3/min
Opportunities of optimization of compressed air use are given in Appendix A10, ECO #10

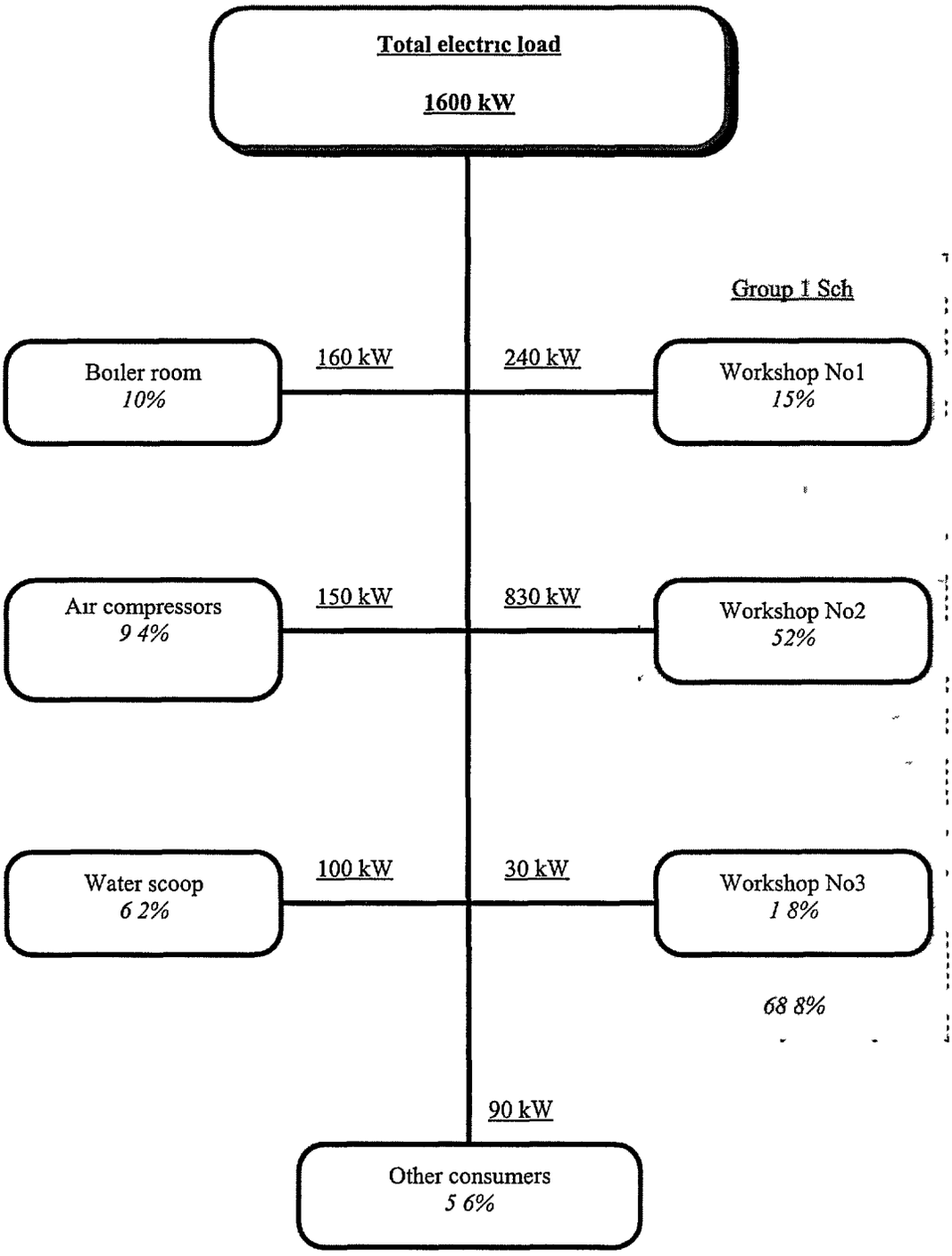
Energy use profile in 1997



#	Thermal energy consumers	Gcal	%
1	BELKOZIN plant	37,254	88 8
2	Butter plant	2,578	6 1
3	Bakery	1,648	3 9
4	Meat processing plant	481	1 2
	TOTAL	41,961	100

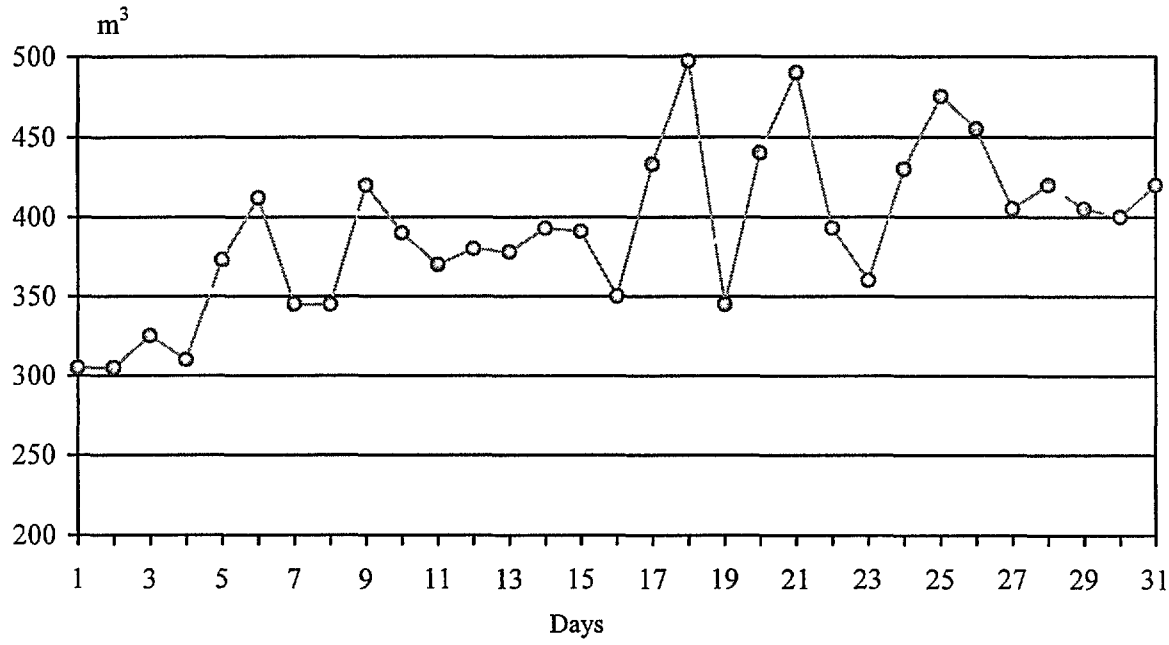
The analysis showed that the BELKOZIN plant sells underpriced cold water and thermal energy to outside customers due to deficiencies of the existing metering system Implementation of a comprehensive energy metering system (see Appendix A 2) will give a realistic picture of energy distribution among the outside customers

Average electricity use balance of BELKOZIN



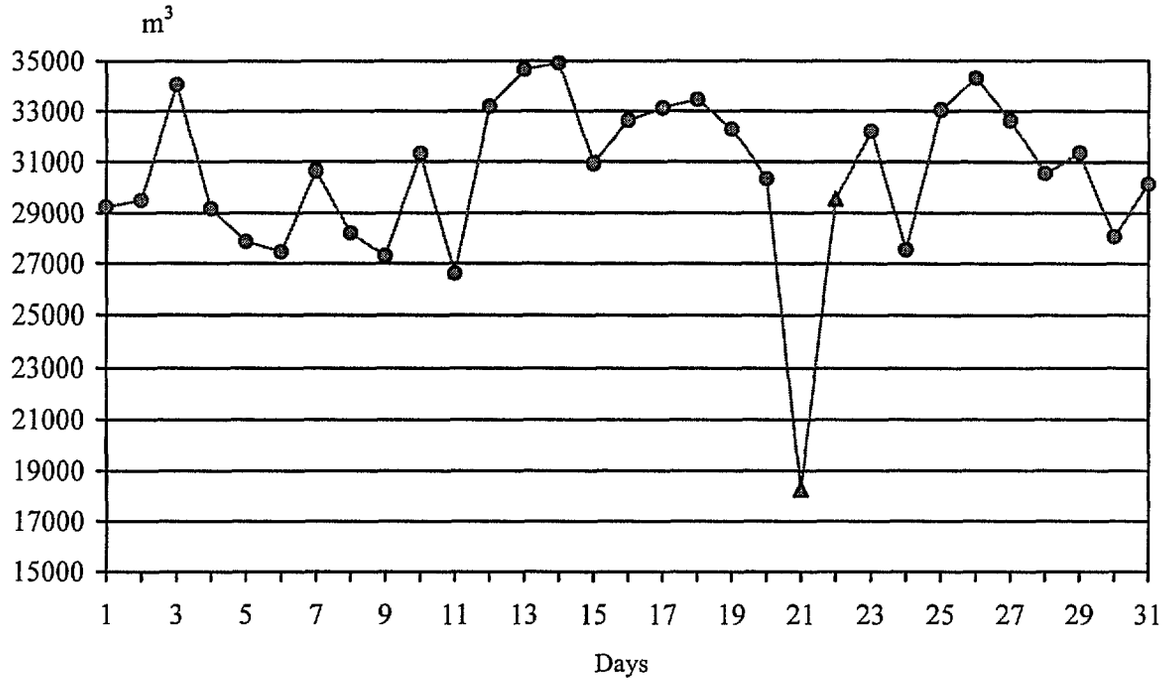
Average electricity balance was drawn on the basis of the plant metering data for March and April 1998 During the audit the balance was corrected using the measurements taken by the audit equipment The most energy intensive consumer is the "1Sch" group using 68 8% of total electric power

Cold water use by the boiler room in March 1998



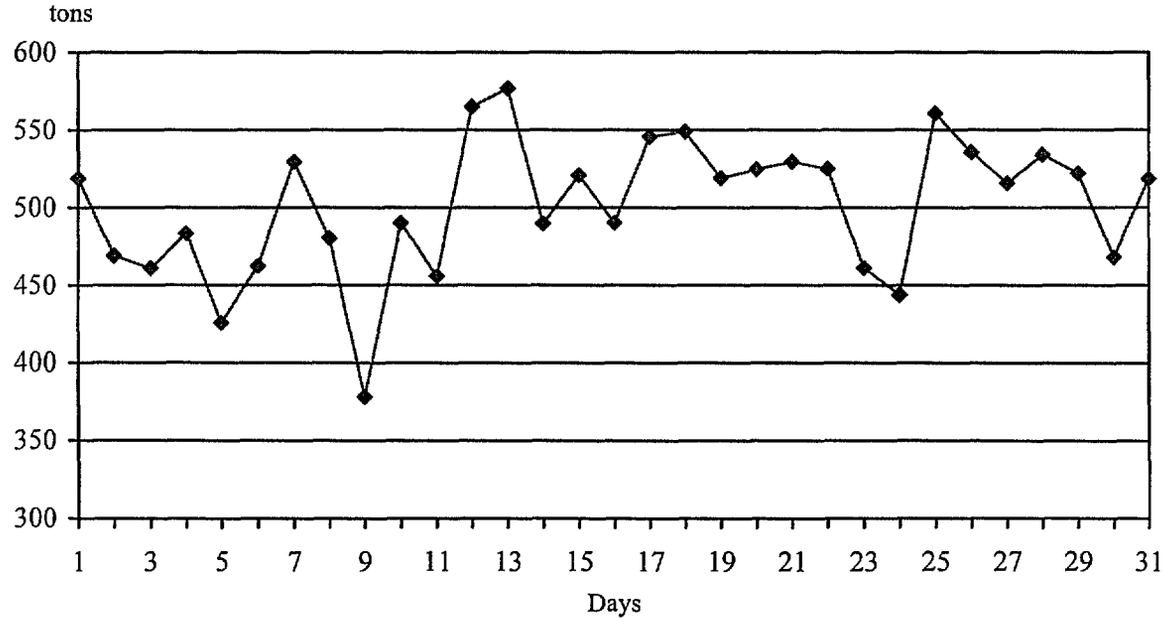
Increased water use by the boiler room is explained by the absence of metering of energy use by the outside customers - by bakery, butter plant and meat processing plant Pressure in the return network pipeline was kept at 0 8 kg/cm^2 instead of necessary 3 5 kg/cm^2 It caused air locks in the heating systems and, by the energy auditors' opinion, to intentional network water leaks by the customers Absence of energy management and shortcomings in organization of heating system operation at the plant and outside customers' sites according to the experts' estimates caused losses to the amount of $40,000

Casinghead gas consumption in March 1998



Drop in gas consumption on March 21-22 was caused by usage of standby fuel - of heavy fuel oil The rest of the dais the unstable fuel consumption was explained by fluctuating heating system operation and drying air heaters depending on the ambient temperatures Unstable gas consumption is explained also by fluctuations of calorific value of the casinghead gas

Steam generation in March 1998



For a more detailed analysis of fuel and steam consumption it is necessary to institute energy management

6 0 RECENT IMPROVEMENTS IN ENERGY CONSERVATION

The auditors were informed about with measures for reduction of fuel and energy consumption implemented by the BELKOZIN in 1997

1 Installation of pumps with 55-kW drives instead of pumps with 160 kW drives on the water supply network will result in power use reduction by 283,500 kWh/year (2 3% of annual consumption

Estimated cost effect - $10,700 per year

2 Insulation of counter-current heater for domestic water heating will reduce thermal energy use by 87 Gcal a year (0 2% of annual consumption)

Estimated cost effect - $1,340 per year

3 Recovery of condensate from water casing cooking heaters to the condensate tanks will reduce energy use by 22 Gcal/year (0 05% of annual consumption)

Estimated cost effect - $360 per year

4 Shut-off of steam and water supply to the saunas of electric supply, instrument and transport units will reduce energy use by 60 Gcal/ year (0 15% of annual consumption), cold water by 1,152 m^3/year (0 15% of annual consumption), sewerage by 1,152 m^3/year (0 21% of annual consumption)

Estimated cost effect - $1,500 per year

5 Recalculation of domestic water consumption and sewerage due to layoffs will reduce cold water use by 1,140 m^3/year (0 15% of annual consumption), sewerage by 1,140 m^3/year (0 21% of annual consumption)

Estimated cost effect - $520 per year

6 Overhaul of DKVR-20-13 boiler insulation will reduce gas consumption by 34,600 m^3/year (0 37% of annual consumption)

Estimated cost effect - $2,680 per year

7 Utilization of hot water heat at the boiler room will reduce thermal energy use by 418 Gcal/year (1 1% of annual consumption)

Estimated cost effect - $6,800 per year

The plant has been and is implementing various organisational and technical energy saving measures dictated by the need to reduce production costs

Unfortunately, the BELKOZIN energy conservation program lacks implementation data and economic results due to the lack of a computerised energy consumption metering and analysis system

7 0 ENERGY AUDIT

As the result of the energy audit at the OJSC BELKOZIN the audit team recommended several proposals for improvement of energy efficiency at the plant The majority of the problems are typical for Ukrainian enterprises so the solutions of these problems can be replicated for enterprises with similar systems of energy use

Introduction of the recommended measures will reduce annual energy consumption
1 Electricity by 6,720,000 kWh (60%)
2 Casinghead gas by 2,743,000 m^3 (41%)

The results of technical and economic calculations of energy conservation opportunities are given below

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 Energy management is a management system based on standard measurements and checks providing for such operation of the plant that ensures only absolutely necessary consumption of energy for production purposes

In order to implement continuous supervision and analysis of energy use we recommend to institute energy management system and provide necessary measuring equipment

Implementation of this project will reduce fuel and energy costs by 103,080 $/year
Payback period will be 0 5 year
See details of this proposal in Appendix A1, ECO #1

ECO #2 -Comprehensive energy metering system

In order to implement energy management and introduction of cost-accounting within the works production units it is necessary to upgrade the existing energy metering system As one of upgrading options we recommend the ITEK technical instrument set which possesses metrological characteristics and is designed for continuous and periodical (express analysis) 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 operation at numerous Ukrainian facilities

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)

Implementation of this project will reduce fuel and energy costs by 51,000 $/year
Payback period will be 1 4 years
See details of this proposal in Appendix A2, ECO #2

ECO #3 - Optimisation of thermal and hydraulic parameters of thermal supply networks

For heating purposes in the boiler house of the enterprise a heating plant is used made up of two heating units Heat generated by the boiler house goes for production and domestic purposes of the BELKOZIN and is sold to outside customers The network temperature schedule is 95 to 70°C The thermal energy consumption shares are as follows

- BELKOZIN plant - 50%
- bakery - 27%
- butter plant - 23%

The temperatures in the supply and recovery pipelines are much higher than scheduled which causes local overheating of buildings, heat waste and increase of gas consumption

To reduce this unjustified waste we recommend

- to optimize the heating system operation not only at the BELKOZIN plant but at the outside customer sites as well
- to operate the heating system according to the schedule

Implementation of this project will reduce fuel and energy costs by 29,800 $/year
Payback period will be 0 6 year
See details of this proposal in Appendix A3, ECO #3

ECO # 4 Thermal energy and electric power co-generation

During the visit to the plant boiler house and heat distribution unit the audit team observed the following steam generation mode

- DKVR 20-13 boiler generated saturated steam with the following parameters

  pressure P_s - 10-12 kg/cm^2 to the amount of G_s = 15-16 tons per hour,, temperature - 350^{0}C,

- at the steam distribution unit the pressure reduction plant steam pressure is reduced to P_s = 5

For the winter season heating operation before the network water heaters a reduction plant is installed for steam pressure reduction from 12 kg/cm^2 to 5-6 kg/cm^2 Steam generation in wintertime reached 28 tons per hour

The energy auditors recommend to install two PVM-250 machines instead of pressure reduction plants for thermal energy and electric power co-generation The rated capacity of the proposed PVM-250 machines will be 500 kW

Implementation of this project will reduce fuel and energy costs by 135,000 $/year
Payback period will be 1 3 year
See details of this proposal in Appendix A4, ECO #4

ECO #5 - Optimisation of combustion control in DKVR-20-13 boilers

The plant is equipped with three boilers of DKVR type There are three major problems with the existing control system

- Instead of air flow, FD fan discharge pressure signal is used This makes air flow control very erratic at low loads and makes automatic excess air correction impossible to achieve

- There is no automatic excess air correction vs load, i e , no oxygen program The system relies on the boiler operator to make an air flow set point adjustment after each load change Of course this doesn't happen and the boiler always operates with too much excess air

- There is no automatic excess oxygen correction because the existing control system is not able to register changes in calorific value of the casinghead gas

We are proposing to resolve all three problems The BELKOZIN plant will fabricate a piezometer ring and install it on the FD fan suction The piezometer ring will serve as an air flow element Additional equipment includes two differential pressure transmitters, an oxygen analyzer, a microprocessor based controller and a variable frequency drive The resultant system will provide true air flow control and an automatic excess air vs load correction It is advisable to replace the GMGB burners with more up-to-date MDGG burners

Implementation of this project will reduce fuel and energy costs by 30,000 $/year
Payback period will be 1 1 year
See details of this proposal in Appendix A5, ECO #5

ECO #6 - Thermal insulation of surfaces with temperatures over 60°C

The results of the steam distribution system analysis showed that some steam pipelines do not have thermal insulation Energy losses due to the lack of insulation are enormous Temperature inside work rooms reaches 40°C at the ambient temperature of 5°C that impairs working conditions

We recommend that the steam piping should be fully insulated The thickness of insulation should be selected dependent on the piping diameter and its purpose

Implementation of this project will reduce fuel and energy costs by 2,300 $/year
Payback period will be 0 5 year
See details of this proposal in Appendix A6, ECO #6

ECO #7 - Utilisation of DKVR-20-13 blowdown heat and water

The BELKOZIN boiler house in 1997 generated around 75,000 tons of steam Blowdown water was 7% on average and was drained into sewer

The energy auditors see it expedient to use the blowdown water to replenish thermal networks which will save water and heat going currently to the sewer It is sufficient to channel the blowdown water to the deaerator replenishment tank of thermal network

Implementation of this project will reduce fuel and energy costs by 11,800 $/year Payback period will be 0 7 year
See details of this proposal in Appendix A7, ECO #7

ECO #8 - Optimisation of the plant electric power supply

The existing electric supply system consists of the DU-10kV distribution unit supplied via two inputs from automatic standby systems of seven transformer substations TP-1 through TP-6 and RU-0 4 kV distribution devices

Total rated capacity is 8,410 kVA
The peak maximum load does not exceed 2,200 kW, peak hourly load in winter is 1 700 kW, in summer - 1,550 kW
Total losses at operational transformers (losses in steel and windings) are 75 kW

Based on the analysis of the average power consumption of the plant (see Section 5 3) where the breakdown of power loads by production units is given it may be concluded that there is a possibility by rearranging the power transformers in accordance with actual loads and reswitching of the cabling to reduce the number of operational power transformers to 5 The losses at the transformers will be 30 kW

Implementation of this project will reduce fuel and energy costs by 15,000 $/year Payback period will be 0 8 year
See details of this proposal in Appendix A8, ECO #8

ECO #9 - Utilisation of used air heat from production lines

Currently the technology of sausage and frankfurter skin includes drying of produce reduction of moisture content of the skin from 88% to 8% The drying agent is a dry hot air of 100-120^{0}C The air heated in air heaters by steam After the drying lines the used humid air of 55-60^{0}C (according to the measurements) is emitted into the atmosphere According to the study of the energy use approximately 17,000 Gcal of heat is lost i e 33% of the heat used by the plant Heat waste per hour amount to 2-2 5 Gcal

The energy audit team recommend a system to recover heat To achieve this it is proposed to install heat exchangers on the heat piping in the air-to-air environment made of stainless steel

Implementation of this project will reduce fuel and energy costs by 90,000 $/year Payback period will be 1 1 years
See details of this proposal in Appendix A9, ECO #9

ECO #10 - Optimisation of compressed air system

Compressed air for production purposes is supplied by two compressors 3SK-240 B1 and VP-20/8
Total capacity of compressors is 36 m^3/min Considering mechanical wear-out of the compressors the maximum capacity does not exceed 30 m^3/min

Considering the length of piping and losses of compressed air during transportation as well as measurements of electric loads of compressors by the "DRANETZ" energy analyzer between 10 and 17 April 1998 actual consumption of compressed air for production purposes was significantly lower than in the information given by the plant

We recommend to install directly in the workshops instead of the existing compressor station small one-unit automatic compressor plants equipped with receivers and motor relays that will reduce the electric power consumption by 50% and significantly lower production costs for the maintenance of compressors
Implementation of this project will reduce energy costs by 100,000 $/year Payback period will be 0 9 year
See details of this proposal in Appendix A10, ECO #10

ECO #11 - Reduction of energy use for operation production refrigeration equipment

One of the primary electric energy users at the plant is an ammonia refrigeration compressor plant The cooling consumers are as follows

- cold room for defrosting,
- cold room for frankfurters,
- cold room for standard sausages,
- cold room for mixing lines

The analysis performed by the energy audit team established that energy losses occur through the gaps in the doors and due to "spilling out" of cold air during loading operations Due to production requirements every 15 minute electric fork-lift trucks move products

In order to reduce cooling generation costs the energy auditors recommend to install at the entrances to the cold rooms plastic curtains that will result in minimizing energy losses Introduction of this ECO will ensure reduction of cooling consumption and, accordingly, of electric power by 5 - 7%

Implementation of this project will reduce energy costs by 2,280 $/year Payback period will be 0 4 year
See details of this proposal in Appendix A11, ECO #11

8 0 ENVIRONMENTAL IMPACT OF RECOMMENDATIONS

The most efficient way of reduction of hazardous emissions into the atmosphere is decrease of fuel and electric power use Energy conservation and efficiency are very beneficial from the ecological standpoint

The proposed project contains energy conservation measures aimed at saving fuel and electric power The main fuel used at the JSC BELKOZIN is casinghead gas The harmful substance that forms in significant quantity during combustion of this fuel is nitrogen oxide (NO_X) The nitrogen oxides are harmful to the human health and can cause severe respiratory problems
Since combustion of gas results in the least emissions of the carbon dioxide CO_2 (that is the main gas responsible for setting "the green house effect"), saving casinghead gas will contribute to weakening of "the green house effect" Carbon monoxide (CO) is emitted after an incomplete combustion of fuel, it reacts with other substances and has various detrimental impacts Sulphur dioxide resulting from combustion destroys materials

Annual energy resource savings due to implementation of energy management will be as shown in the Table1
1 Electricity saving - 6,720,000 kWh (60%
2 Casinghead gas saving - 2,743,000 m^3 (41%)

According to the data from the Ministry of Energy, in 1996 1 kW h of the electric power meant emitting into the atmosphere of 17 g of contaminating substances, including the following

sulphur dioxide SO_2	9 9 g
carbon oxide CO	0 5 g
nitrogen oxides NO_x	2 2 g
solid particles	4 4 g

Reducing electric consumption results in decreasing the amount of the emitted harmful substances that can be determined by the formula

$$h = h_n \quad E_{ps},$$

where

h_n - the specific content of emissions, g/kW h
E_{ps} - electric power saving, kW h

Amounts of pollutants formed during generation of 6,720,000 kWh

1) sulphur dioxide SO_2	h_1 = 9 9 x 6,720,000 = 66,528,000 (g/year)
2) carbon oxide CO	h_2 = 0 5 x 6,720,000 = 3,360,000 (g/year)
3) nitrogen oxides NO_x	h_3 = 2 2 x 6,720,000 = 14,784,000 (g/year)
4) solid particles	h_4 = 4 4 x 6,720,000 = 29,568,000 (g/year)

Calculation of the carbon oxide that forms after combustion of coke-oven gas is made by the formula

$$M_{CO} = 0\ 001 \quad B \quad K_{CO} \quad Q_r\ (1 - q/100),$$

where

B - consumption of casinghead gas, m^3/yr

K_{CO} = 0 25 kg/GJ - the quantity of carbon oxide that is produced per heat unit released after combustion of casinghead gas

Q_r = 37 MJ/m^3 - the lowest calorific value of natural fuel

q = 0 5 % - heat losses resulting from an incomplete gas combustion

M_{CO} = 0 001 2,743,000 0 25 37 (1 - 0 5/100) = 25,000 (kg/yr),

or

M_{CO} = 25 t/yr

Calculation of the nitrogen oxides per time unit (t/yr) shall be done by the formula

M_{NOx} = 0 001 B K_{NOx} Q_r (1 - b),

where

K_{NOx} = 0 1 kg/GJ - a parameter characterising the amount of the nitrogen oxides forming per 1 GJ of heat, kg/GJ,

b = 0 15 - a coefficient for taking into account the degree of decreasing the level of emissions of nitrogen oxides resulting from implementation of technological measures

M_{NOx} = 0 001 2,743,000 0 1 37 (1 - 0 15) = 8,600 (kg/yr),

or

M_{NOx} = 8 6 t/yr

Implementation at the BELKOZIN plant of energy conservation measures will decrease the energy resource consumption, and in its turn lower the quantity of harmful emissions into the atmosphere

TABLE OF POLLUTANT EMISSION REDUCTION

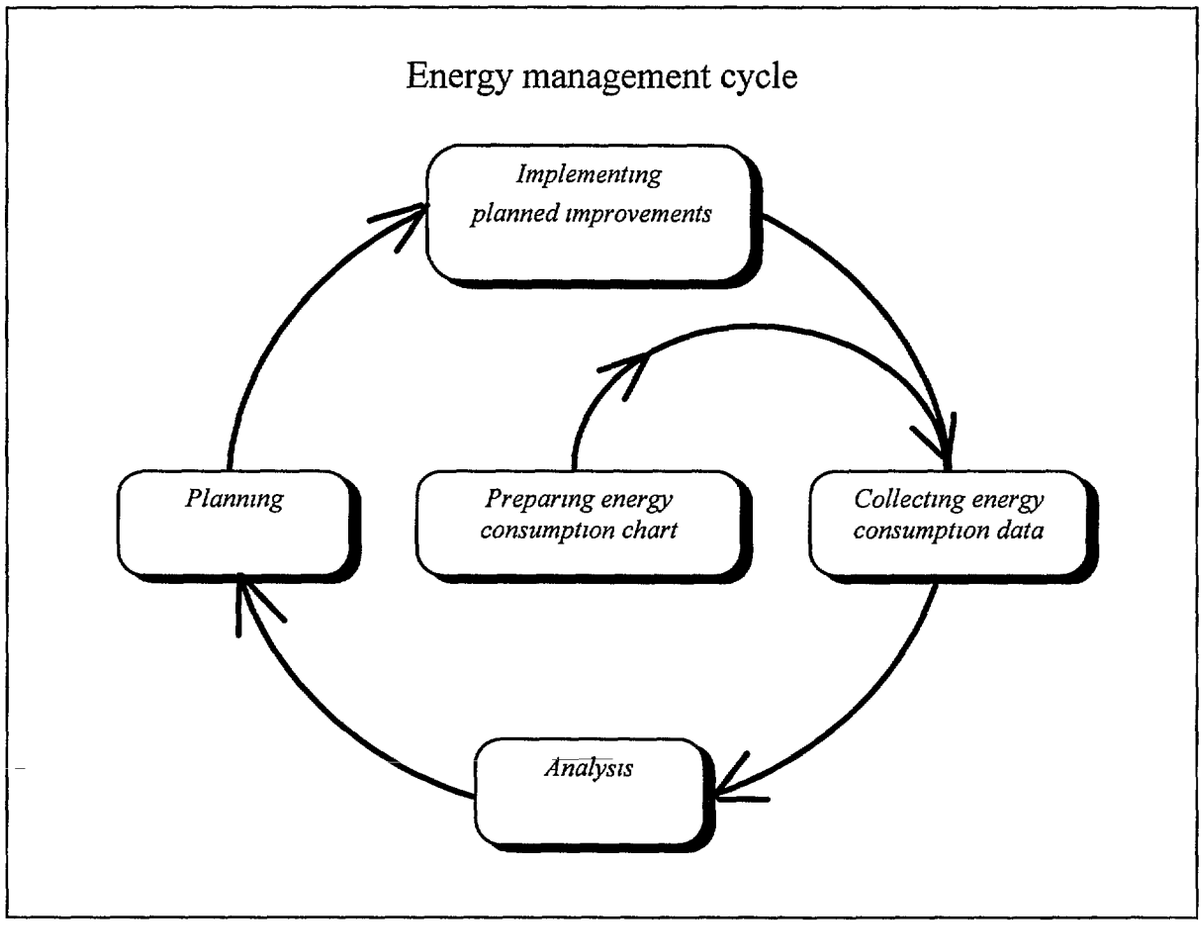
	Reduction in emissions as result of the energy savings, t/yr		
Emissions	**Electric power**	**Casinghead gas**	**TOTAL**
Hard particles	29 6		29 6
Sulphur dioxide	66 5		66 5
Carbon oxide	3 3	25	28 3
Nitrogen oxides	14 8	8 6	23 4
Total emission reduction			147 8

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

Implementing an energy management activity typically would involve establishing a separate section of employees to deal only with energy efficiency At a minimum an energy management section should consist of three people technical supervise, an electric engineer and a thermal engineer

The main duties of an energy management section include

- Preparing facility's energy consumption chart (probably in collaboration with an outside consultant, energy auditor),
- 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,
- Implementing new technologies on existing and new energy systems to improve energy efficiency of operation,
- Encouraging the personnel to indicate potential energy conservation opportunities
- Keeping informed on current energy policy trends and neighboring issues, (e g , such as new tax legislation, existing consumption restrictions, subsidies, environmental aspects etc)

In order to implement permanent energy consumption monitoring and analysis we recommend to institute energy management system at the plant and to provide required measuring equipment The set of equipment that will be useful for the plant should include

- three phase energy analyzer,
- tachometer,
- hot-wire anemometer,
- combustion analyzer,
- non-contact thermometer,
- ultrasonic leak detector,
- digital contact thermometer,
- light meter,
- power factor meter,
- portable temperature/humidity/ dew point meter,
- computer with printer

Annual energy savings

Currently the works use annually on average 11,100,000 kWh of electric power, and 6,620,000 m^3 of natural gas
Typically, combustion efficiency improves by 2 5% from utilizing the combustion analyzer Electric power use efficiency can be linked to a wide range of factors i g power factor correction, improvement of equipment load control (shutting off idling equipment), optimization of motor loads, optimization of pump operation, improvement of compressor load control On average improvement of electric power use can ensure from 3 to 10% savings of total electric power consumption
The global experience and practice show that in case of institution of full-time energy management ensures 10% of fuel and energy consumption savings Energy savings will amount to
1) Electric power - 11,100,000 x 0 1 = 1,110,000 (kWh)
2) Natural gas - 6,620,000 x 0 1 = 662,000 (m^3)

Annual cost saving estimate

1 At the price of $0 038 per 1 kWh of electric power the cost savings will be
1,110,000 x 0 038 ~ $42,180
2 At the price of $0 092 per 1 m^3 of natural gas the cost savings will be
662,000 x 0 092 ~ $60,900

TOTAL energy cost savings will be
42,180 + 60,900 ~ $103,080

Implementation Costs

Cost of instituting three energy management based on past projects is around 50% of expected savings

103,080 x 0 5 = $51,540

Simple payback

Implementation costs - $51,540
Annual cost savings - $103,080
Simple payback period will be
51,540/103,080 = 0 5 (year)

A 2 ECO # 2 COMPREHENSIVE ENERGY METERING SYSTEM

ECO description

Energy and fuel consumption monitoring and precise breakdown of this consumption by production lines and units is one of the basic tools of energy management This will provide a realistic depiction of the energy balance of the enterprise, opportunity of energy use assessment and viable possibility of fuel consumption dependent on the equipment characteristics and workloads

Though the existing TzT-5000 system of electric power metering shows a partial picture of electricity consumption and distribution among production lines, however, it requires upgrading and expansion of features Thermal energy metering system of the works combines utilization of instrument metering and theoretical calculations and this precludes provision of realistic thermal energy consumption figures

In order to implement energy management and introduction of cost-accounting within the works production units it is necessary to upgrade the existing energy metering system As one of upgrading options we recommend the ITEK technical instrument set in combination with the TzT-5000 system which possesses metrological characteristics and is designed for continuous and periodical (express analysis) measurement/registration of physical values

Introduction of the ITEK energy metering system in combination with the TzT-5000 system will enable the plant to measure use of the following

- electric power
- natural gas
- heat generation
- cold water supply
- hot water supply

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 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 TzT-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 compliance with the requirements of RD-50-213-80, PR-34-&0-010-85, State standard 6651-84 and P75 recommendation of the Ministry of Health The ITEK-X20 devices are 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)

PRD is a wide range pressure difference converter The PRD measurement device is designed for operation in automatic monitoring and control systems of technological processes and provides continuous conversion of the measured parameter into a uniform electric output signal It is a fast operating converter and can be utilized for conversion of pulsating pressure differences into a unified electric signal with time constant of up to 2 msec (maximum permissible operational excess pressure is 1 6 Mpa and 40 MPa)

Annual energy savings

In 1997 the works used approximately 11,000,000 kWh of electric power, 6,600,000 m^3 of casinghead gas
The global experience and practice confirm that quality monitoring of energy ensure 5% of fuel and energy consumption savings Energy savings at the works will amount to
1) Electric power - 11,000,000 x 0 05 = 550 (thousand kWh)
2) Casinghead gas- 6,600,000 x 0 05 = 330 ((thousand m^3)

Annual cost saving estimate

1 At the price of $0 033 per 1 kWh of electric power the cost savings will be 550,000 x 0 033 ~ $21,000
2 At the price of $92 per 1,000 m^3 of casinghead gas the cost savings will be 330,000 x 92 ~ $30,000

Total fuel cost savings will be
21,000 + 30,000 ~ $51,000

Implementation Costs

Approximate cost of the ITEK automatic metering system and TzT-5000 upgrading is $70,000

Simple payback

Implementation costs - $70,000
Annual cost savings - $51,000
Simple payback period will be
70,000/51,000 ~ 1 4 (years)
Note This proposal is a component of energy management In this project it is viewed separately

A 3 ECO # 3 OPTIMISATION OF THERMAL AND HYDRAULIC PARAMETERS OF THERMAL NETWORKS

ECO description

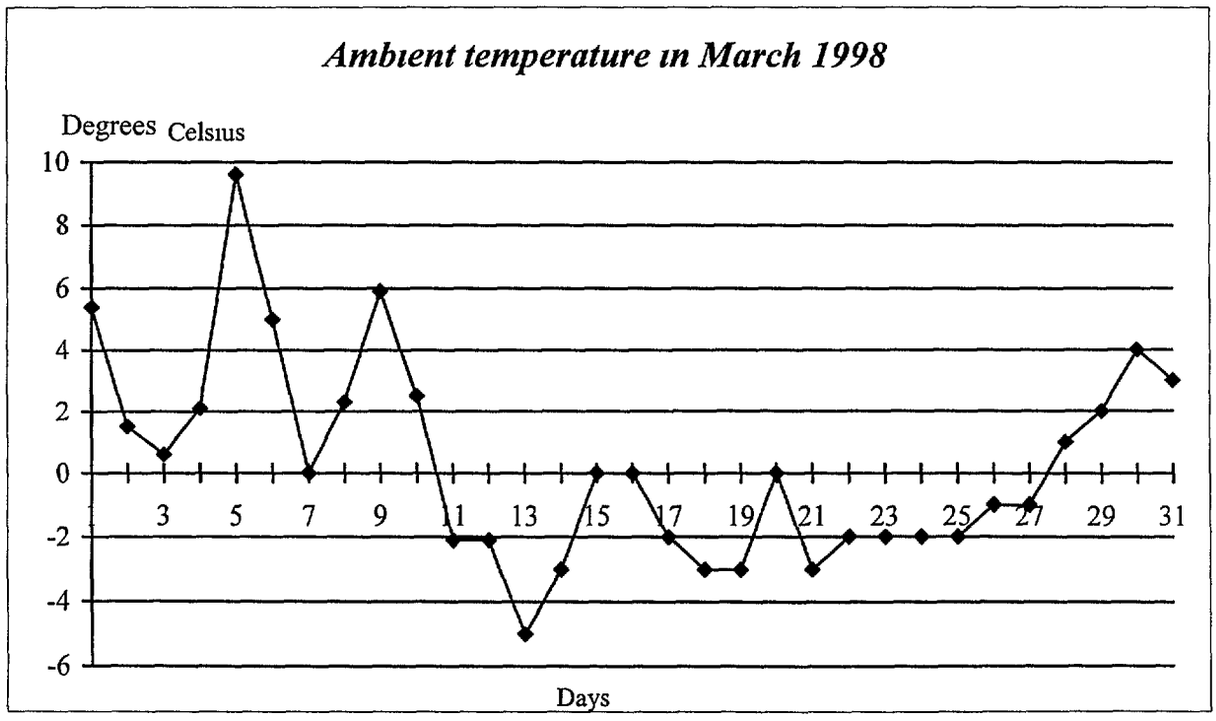
For heating purposes in the boiler house of the enterprise a heating plant is used made up of two heating units Each unit comprises a steam-to water heater of 0,5 OST 34-532-68 type with surface area of 53 4 m^2 and a water-to-water heater (condensate cooler) of 14 OST 34-588-68 type with surface area of 20 3 m^2 In the boiler room there are four network pumps In the summer season 6NDV- type pumps are operated with the head of 54 meters of water column and pumping capacity of 250 m^3 / hour In wintertime TzN-450/105 pumps are operated with 160 kW motors The network temperature schedule is 95–70°C The thermal energy consumption shares are as follows

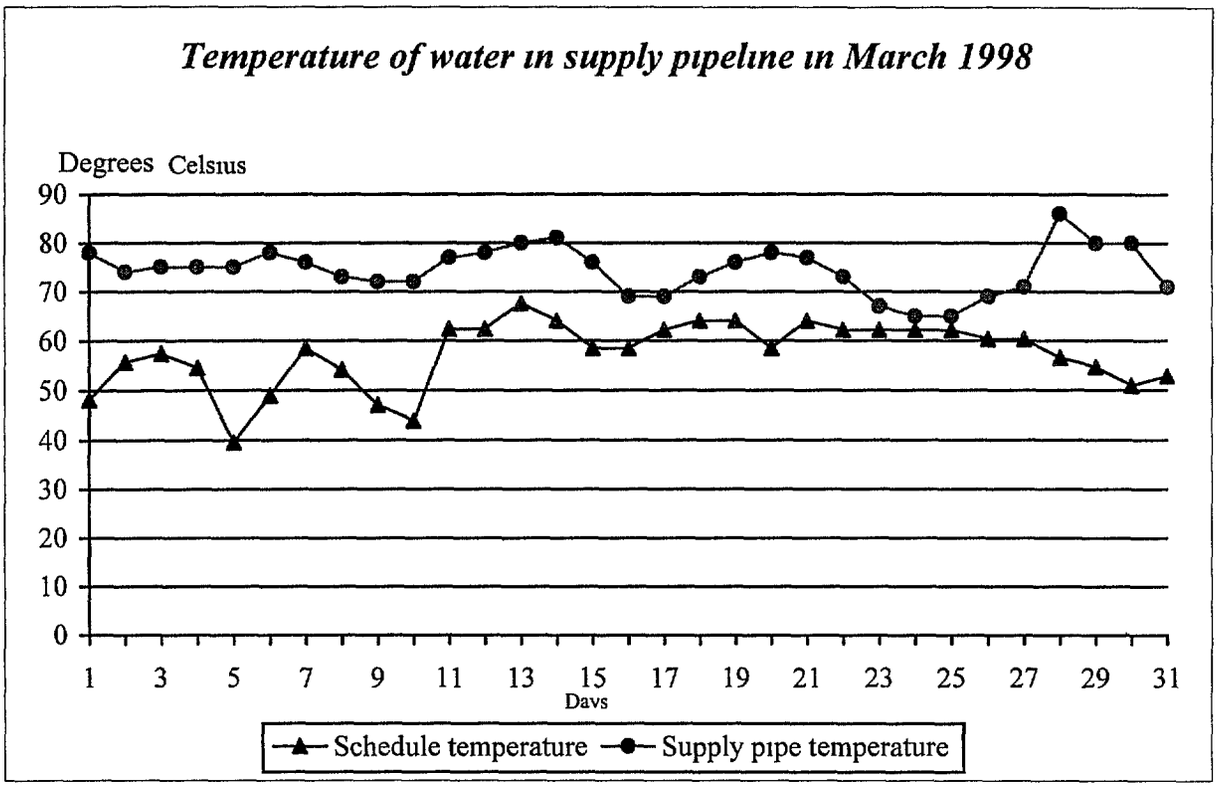
- BELKOZIN plant - 50%
- bakery - 27%
- butter plant - 23%

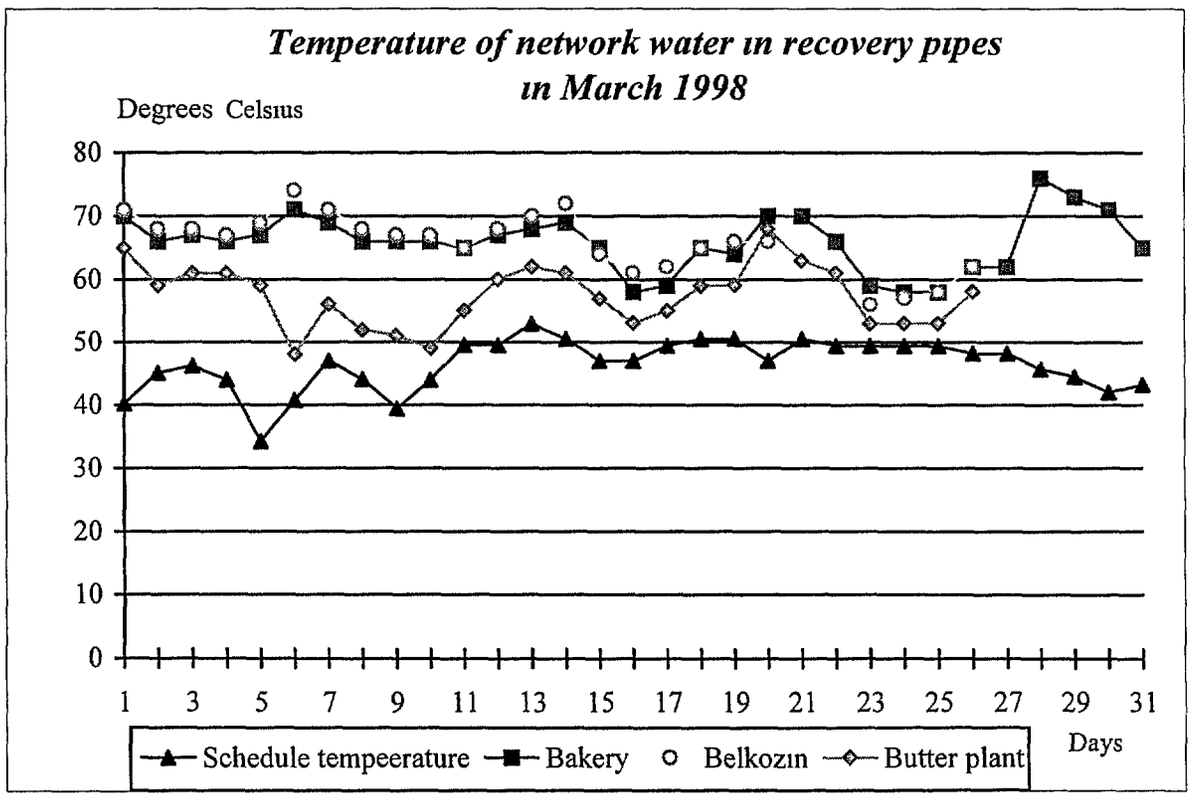
Below are the charts of ambient temperatures and temperatures of the network water for space heating

- at the boiler output header
- at recovery pipelines before the network pump manifold

depending on the ambient temperature in conformity with the temperature schedule of 95°–70° in March 1998




Temperature of water in supply pipeline in March 1998
Degrees Celsius
90
80
70
60
50
40
30
20
10
0
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31
Days
Schedule temperature
Supply pipe temperature


Temperature of network water in recovery pipes in March 1998
Degrees Celsius
80
70
60
50
40
30
20
10
0
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31
Days
Schedule tempeerature
Bakery
Belkozin
Butter plant

As seen from the charts the temperatures in the supply and recovery pipelines are much higher than scheduled which causes local overheating of buildings, heat waste and increase of gas consumption

To reduce this unjustified waste we recommend

- to optimize the heating system operation not only at the BELKOZIN plant but at the outside customer sites as well
- to operate the heating system according to the schedule

Energy savings estimate

If we assume that a network pump runs to 80% of its capacity then heat generation will be

250 × 0 8 × 12 / 1,000= 2 4 (Gcal/hour)

The BELKOZIN load is 50% of this figure i e 1 2 Gcal/hour

The heating load at the ambient temperature t = -21°C is 0 964 Gcal/hour It may be assumed that overheating of the buildings is

1,2 / 0 964 × 100 - 100 ≈ 25 (%)

Estimated heat consumption during the heating season at 80% load of the network pump with the temperature difference between the supply and recovery pipelines of 12°C on average will be

250 × 0 8 × 12 × 24 × 189 / 1,000 ≈ 10,900 (Gcal/year)

Reduction of thermal energy use for heating to the scheduled figure (by 25%) will be

10,900 × 0 25 ≈ 2,700 (Gcal/year)

At the specific consumption of gas at 120 m^3/Gcal the savings will be

2,700 × 120 ≈ 324,000 (m^3/year)

Cost savings estimate

At the gas price of 0 092$ per 1 m^3 the savings will be

324,000 × 0 092 ≈ 29,800 ($)

Implementation cost

Study of the heating systems at the BELKOZIN plant, butter plant, bakery, meat processing plant and development of measures for optimization of thermal networks and internal heating systems	- 5,000$
Implementation of the measures	- 5,000$
Optimization of thermal and hydraulic operation modes of thermal networks and heating systems	- 5,000$
Contingencies and overheads	- 3,000$
TOTAL costs	- 18,000$

Simple payback

Implementation cost	- 18,000 $
Annual cost savings	- 29,800 $

Simple payback will be

18,000 / 29,800 ≈ 0 6 (year)

With the duration of the heating season of 6 months a year the payback period will be 3 months

A 4 ECO - 4 THERMAL ENERGY AND ELECTRIC POWER CO-GENERATION

ECO description

During the visit to the plant boiler house and heat distribution unit the audit team observed the following steam generation mode

- DKVR 20-13 boiler generated saturated steam with the following parameters

  pressure P_s - 10-12 kg/cm^2 to the amount of G_s = 15-16 tons per hour, temperature - 350^{0}C,

- at the steam distribution unit the pressure reduction plant steam pressure is reduced to P_s = 5 kg/cm^2

For the winter season heating operation before the network water heaters a reduction plant is installed for steam pressure reduction from 12 kg/cm^2 to 5-6 kg/cm^2 Steam generation in wintertime reached 28 tons per hour

The energy auditors recommend to install 2 PVM-250 machines instead of pressure reduction plants for thermal energy and electric power co-generation The rated capacity of the proposed PVM-250 machines will be 500 kW

This measure will reduce the volume of purchased power and lower share of energy costs in total production costs

Annual energy savings estimate

The operation mode will be round the clock 330-340 days a year Electric power generation by the in-plant sources - two PVM-250 - will be

500 x 24 x 330 = 3,960,000 (kWh)

i e electricity use from electric grids will be 3,960,000 kWh less

Annual cost savings estimate

Cost savings by reduction of externally purchased power at the price of $0 034 per 1 kWh will be

3,960,000 x 0 034 = $135,000

Implementation costs

By the experts' estimate

Design - $50,000

Cost of 2 PVM-250 - $120,000

Turnkey installation - $40,000

Overheads and contingencies at 25% - $15,000

Total costs - $180,000

Simple payback

Implementation costs - $180,000

Annual cost savings - $135,000

Simple payback period will be
180,000/135,000 ~ 1 3 years

A 5 ECO #5 OPTIMIZATION OF COMBUSTION CONTROL IN DKVR-20-13 BOILERS

ECO description

The Plant has three boilers made by the Biysk boiler works (Russia) There are thousands of such boilers operating in Ukraine While this recommendation doesn't have the best payback of all recommendations for this plant, the audit team decided to assign first priority to this ECO due to vast possibilities for replication

The combustion control strategy used for this boiler is standard for all small boilers in the N I S This strategy cannot be called anything but primitive The design dates back to 1960 and conforms to the Soviet Union standards The combustion control strategy used in the USA by the Bailey Co in 1920 was better As result, the excess air ranges from 31% to 80% at the boiler exit and from 50% to 100% at the ID fan suction

There are three major problems with the existing control system

- Instead of air flow, FD fan discharge pressure signal is used This makes air flow control very erratic at low loads and makes automatic excess air correction impossible to achieve

- There is no automatic excess air correction vs load, i e , no oxygen program The system relies on the boiler operator to make an air flow set point adjustment after each load change Of course this doesn't happen and the boiler always operates with too much excess air

- There is no automatic excess oxygen correction because the existing control system is not able to register changes in calorific value of the casinghead gas

We are proposing to resolve all three problems The BELKOZIN plant will fabricate a piezometer ring and install it on the FD fan suction The piezometer ring will serve as an air flow element Additional equipment includes two differential pressure transmitters, an oxygen analyzer, a microprocessor based controller and a variable frequency drive The resultant system will provide true air flow control and an automatic excess air vs load correction It is advisable to replace the GMGB burners with more up-to-date MDGG burners

It is possible to operate DKVR-20-13 boiler at 1-2% excess air at the boiler exit and 10% excess air at the ID fan suction under an automatic excess air vs load correction Such operation will result in 5 to 6% savings in fuel (casinghead gas)

Annual Fuel Cost Savings

In 1997 casinghead gas use by the boiler house was 6,620,000 m^3 5% savings of the gas will

6,620,000 x 0 05 ~ 330,000 m^3

Annual cost savings estimate

With the price of gas at $0 092 per 1 m^3 the savings will be

330,000 x 0 092 ~ 30,000 ($)

Implementation Costs

1 Cost of Equipment

• Two differential pressure transmitters	$2,500
• One microprocessor based controller	$2,500
• One oxygen analyzer	$4,000
• One variable frequency drive, 37 kW	$2,500
• Shipping and handling	$2,000
• MDGG burners (3)	$9,000
TOTAL equipment costs	$24,500

2 Cost of Installation and Commissioning

- Installation labor and materials will be provided by the plant These expenses are negligible

• Technical supervision and commissioning will cost	$5,000
• Registration and commissioning	$1,500
• Contingencies and overheads	$1,500
TOTAL installation and commissioning costs	$8,000
TOTAL Implementation Cost	$32,500

Simple Payback

Implementation cost	$32,500
Annual cost savings	$30,000

Simple payback

$32,500/$30,000 = 1 1 years

A 6 ECO # 6 THERMAL INSULATION OF SURFACES WITH TEMPERATURES OF OVER 60°C

ECO description

The steam generated at the boiler house is used extensively for production needs of the plant and for space heating Additionally steam is supplied by pipelines to the butter plant and meat processing plant who purchase thermal energy from the BELKOZIN

The analysis of the steam distribution system resulted in the findings that some of the pipelines and equipment units are not thermally insulated The energy losses are due to the lack of insulation at pipelines and were measured by the infra-red remote thermometer

Particulars of non-insulated piping are given in the table below

#	Purpose of piping	Location	Length, L m	Diameter, D mm	Number of valves	t, °C
1	Steam	Steam distribution unit	1	40	1	96
2	Steam	Steam distribution unit	1	219	1	100
3	Steam	Steam distribution unit	1	102	1	118
4	Steam	Steam distribution unit	0 5	219	1	102
5	Steam	Steam distribution unit	1	50	1	79
6	Steam	Steam distribution unit	10	108	2	91
7	Steam	Air equipment hall	1	89	3	150
8	Steam	Air equipment hall	3	40	3	93
9	Steam	Air equipment hall	0 4	400	1	155
10	Steam	Skin boiling unit	1 5	30	1	110
11	Steam	Neutralizing solution preparation unit	10	40	1	130
12	Steam	the same	20	40	-	140

The gives the results of measurement of external surface temperatures

Annually the steam is consumed 7,200 hours on average

We recommend that the steam piping should be fully insulated The thickness of insulation should be selected dependent on the piping diameter and its purpose

	Purpose	Diameter, mm	Insulation thickness, mm
1	Steam	102 - 219	100
2	Steam	50 - 89	80
3	Steam	30 - 50	40

Annual energy savings estimate

We should determine thermal energy waste for insulated and non-insulated pipes according to the methodology below [Methodological instructions for determination of losses of fuel and energy resources RD5 EDIV 015-008094 Minmashprom, Kiev, 1994]

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

$Q_{nin} = g_{nin} \times L_o \times k$

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

k - correction factor depending on the outside temperature and difference between pipe outer wall and outside temperatures,

L_o - given length of piping, m

$L_o = L + (1m \times n) = 1 + (1m \times 1) = 2$ (m)

n - number of valves within the section

For the pipeline #1 from the Table we have

$Q_{nin1} = 140 \times 2 \times 0\ 95 = 266$ (kcal/hour)

Further calculations were carried out similarly and are summarised in the Table below

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

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

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

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

t_2 - temperature of 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 200 °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 with thermal conductivity of 0 03 - 0 05 kcal/ (m x hr x ° C) We assume the use of these piping insulation materials

For pipeline #1 from the Table

Q_{int} = 0 231 x (96 - 40) x 1 x 1 09 x 2 = 238 kcal/hr

Similar calculations were carried out for all pipelines and are shown in the Table The savings are received taking into account the length of a pipeline

Pipeline No	Given length L_o, m	Thermal waste without insulation Q_{min}, kcal/hr	Thermal waste with insulation Q_{in}, kcal/hr	Savings S_N, kcal/hr
1	2	266	28	238
2	2	912	45	867
3	2	684	38	648
4	1 5	684	33	651
5	2	190	20	170
6	12	3,420	147	3,273
7	4	1,064	108	956
8	6	798	60	738
9	1 4	2,660	35	2,625
10	2 5	285	50	235
11	10	7,220	277	6,943
12	20	3,800	604	3,196
TOTAL				20,540

In the air equipment hall there are heat losses at the valves The losses at a single valve are considered equal to 1 m of non-insulated piping

$Q_2 = n\ (Q_{2\ min} \times Q_{2\ in})$

where

n - number of valves

Q2 = 100(870-50) = 8,200 (kcal/hour)

Annual savings will be

$Q = 7{,}200(Q_1 + Q_2) = 7{,}200\ (20{,}450 + 8{,}200) = 207{,}000{,}000$ (kcal/year)

or

Q = 207 Gcal/year

Specific consumption of gas is b = 120m^3/Gcal

Annual gas savings will amount to

Q x b = 207 x 120 = 25,000 (m^3/year)

Annual cost savings estimate

Cost savings at the natural gas price of US$0 092 per 1 m^3 will be

2,500 x 0 092 = 2,300 ($/year)

Implementation cost

Insulation costs for steam piping is calculated by the formula

Z = L x C
where
L is total given length of steam piping, m,
C equals US$20/m - cost of 1 m of piping insulation,

Z = 50 x 20 = 1,000 (US$/year)

Total estimated costs of insulation to be installed at the enterprise will be	US$1,000
Overheads 20%	US$200
TOTAL	US$1,200

Simple payback estimate

Annual savings	US$2,300
Implementation costs	US$1,200

Simple payback
1,200/12300 = 0 5 (year)

A 7 ECO#7 UTILIZATION OF DKVR-20-13 BLOWDOWN HEAT AND WATER

ECO description

The BELKOZIN boiler house in 1997 generated around 75,000 tons of steam Blowdown water was 7% on average and was drained into sewer The blowdown water quality corresponds the quality of the thermal network water

The energy auditors see it expedient to use the blowdown water to replenish thermal networks which will save water and heat going currently to the sewer It is sufficient to channel the blowdown water to the deaerator replenishment tank of thermal network

Annual energy savings estimate

The boiler house in 1997 generated around 75,000 tons of steam
Seven per cent of blowdown water is equal to
75,000 x 0 07 = 5,250 (tons)
Amount of heat lost by blowdown at the enthalpy of original water of 0 020 Gcal/ton and enthalpy of blowdown water of 0 180 Gcal/ton is equal to
Q = 5,250 x (0 180 - 0 020) ~ 9,350 (Gcal)
At the specific consumption b ~ 130 nm^3/Gcal energy savings will be
Q x b ~ 9,350 x 130 ~ 122,000 (nm^3)

Annual cost savings estimate

With the price of gas at $0 092 per 1 nm^3 cost savings will be
122,000 x 0 092 = 11,200($)
With the price of water at $0 12 per 1 m^3 cost savings will be
5,250 x 0 12 ~ $600
TOTAL cost savings will be
11,200 + 600 = 11,800 ($)

Implementation costs

By the experts' estimate

- Design - $1,000
- Materials and labor - $3,000
- Turnkey installation - $2,000
- Overheads and contingencies - $2,000

Total costs - $8,000

Simple payback

Implementation costs - $8,000

Annual cost savings - $11,800

Simple payback period will be

8,000/11,800 ~ 0 7 year

A 8 ECO#8 OPTIMIZTION OF THE PLANT ELECTRIC SUPPLY

ECO description

The existing electric supply system consists of the DU-10kV distribution unit supplied via two inputs from automatic standby systems of seven transformer substations TP-1 through TP-6 and RU-0 4 kV distribution devices Distribution of loads for transformer substations is as follows

1 TP1 - 4 x 1,000 kVA - main building
2 TP2 - 2 x 400 kVA - weighing room
3 TP3 - 1 x 400 kVA - compressor room
4 TP4 - 1 x 250 kVA - deep well No3
5 TP5 - 2 x 1,000 kVA - boiler house
6 TP of water scoop - 2 x 400 kVA
7 TP6 - 1 x 160 kVA - deep well No 2

Total rated capacity is 8,410 kVA
The peak maximum load does not exceed 2,200 kW, peak hourly load in winter is 1 700 kW, in summer - 1,550 kW
Total losses at operational transformers (losses in steel and windings) are 75 kW

Based on the analysis of the average power consumption of the plant (see Section 5 3) where the breakdown of power loads by production units is given it may be concluded that there is a possibility by rearranging the power transformers according to actual loads and reswitching of the cabling to reduce the number of operational power transformers to 5 The rest can be left as a cold standby The losses at the transformers will be 30 kW This will minimize the losses of power at the transformers

Annual energy savings estimate

The losses of the plant if going over to the operation of five transformers will drop from 75 to 30 kW If operated 8,640 hours a year the energy savings will be
(75-30) x 8,640 ~ 390,000 (kWh)

Annual cost savings estimate

By reducing the purchases of electric power at the price of $0 038 per 1 kWh the savings will be
390,000 x 0 038 ~ $15,000

Implementation costs

Cost of cabling - $7,000
Installation cost - $5,000
TOTAL costs - $12,000

Simple payback

Implementation costs - $12,000
Annual cost savings - $15,000

Simple payback period will be

12,000/15,000 ~ 0 8 year

A 9 ECO #9 UTILIZATION OF USED AIR HEAT FROM PRODUCTION LINES

ECO production

Currently the technology of sausage and frankfurter skin includes drying of produce reduction of moisture content of the skin from 88% to 8% The drying agent is a dry hot air of 100-120°C The air heated in air heaters by steam After the drying lines the used humid air of 55-60°C (according to the measurements) is emitted into the atmosphere Besides, according to the study of the energy use performed earlier by specialized organizations approximately 17,000 Gcal of heat is lost i e 33% of the heat used by the plant Heat waste per hour amount to 2-2 5 Gcal

The energy audit team recommend to introduce the system of utilization the emitted air heat To achieve this it is proposed to install heat exchangers in the heat piping in the air-to-air environment made of stainless steel

In order to introduce this proposal it is necessary to channel cold air from the common intake to the used air exhaust where utilizer heat exchangers should be installed In the heat exchangers used air will be cooled from 60°C to 25-20°C and emitted into the atmosphere and cool dry air will be heated to 23-27°C After that the dry air will be channeled via the existing recirculation line to the drying line

Introduction of this proposal will reduce consumption of thermal energy by the drying lines by 20-30% i e by 1 Gcal per hour

Annual energy savings estimate

If operated 330 days a year energy savings will be
1 x 24 x 330 ~ 7,900 (Gcal/year)
With specific consumption of gas at 120 m^3 gas savings will be
7,900 x 120 ~ 950,000 (m^3)

Annual cost savings estimate

At the price of $0 092 per 1 m^3 of gas the savings will be
950,000 x 0 092 ~ $90,000

Implementation costs

Design - $15,000
Equipment
- utilizer heat exchangers- $40,000
- air ducts and insulation - $10,000

Installation - $25,000
Overheads and contingencies - $10,000
TOTAL costs - $100,000

Simple payback

Implementation costs - $100,000

Annual cost savings - $90,000

Simple payback period will be
100,000/90,000 ~ 1 1 years

A 10 ECO #10 OPTIMISATION OF COMPRESSED AIR SYSTEM

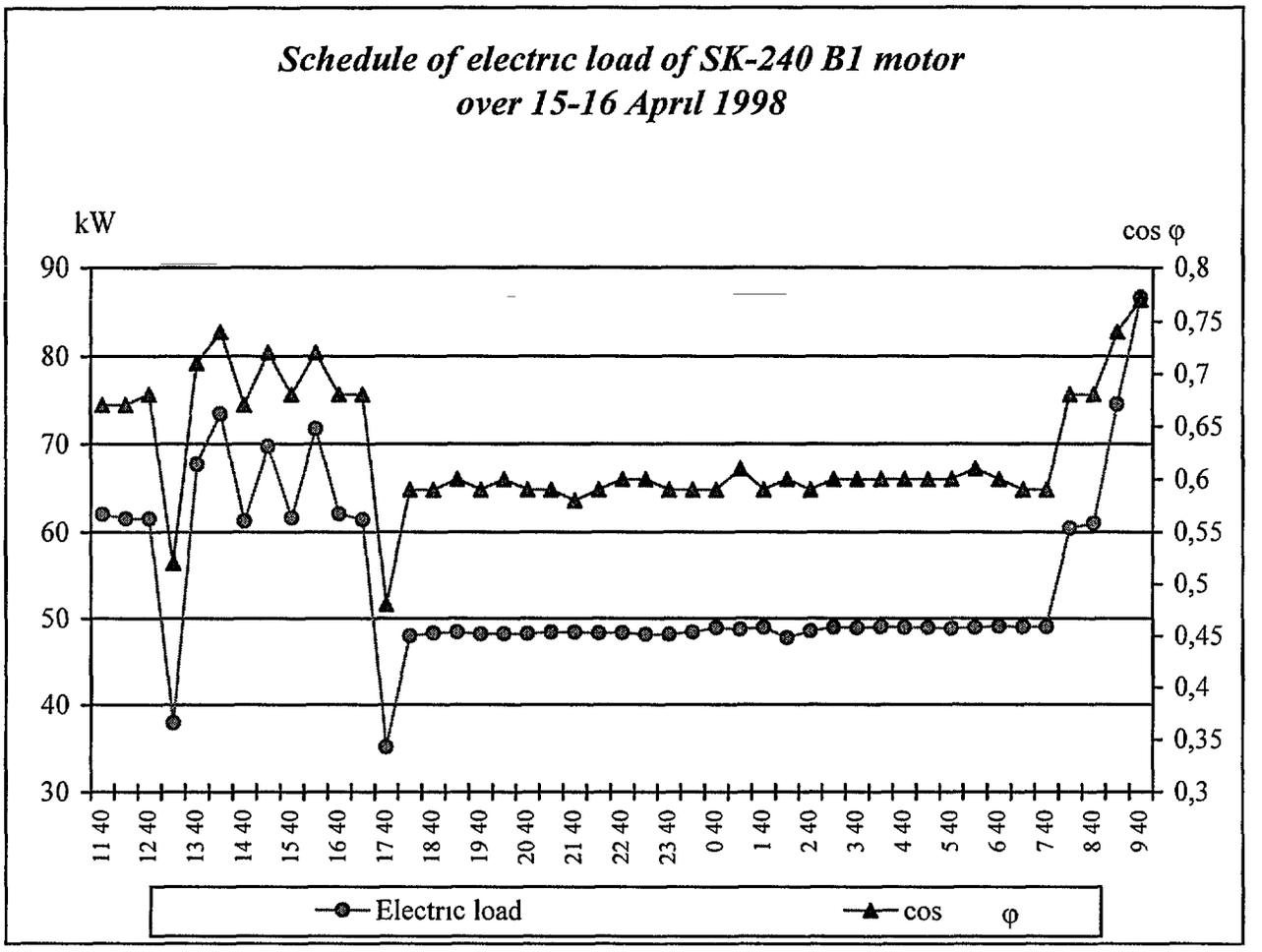
ECO description

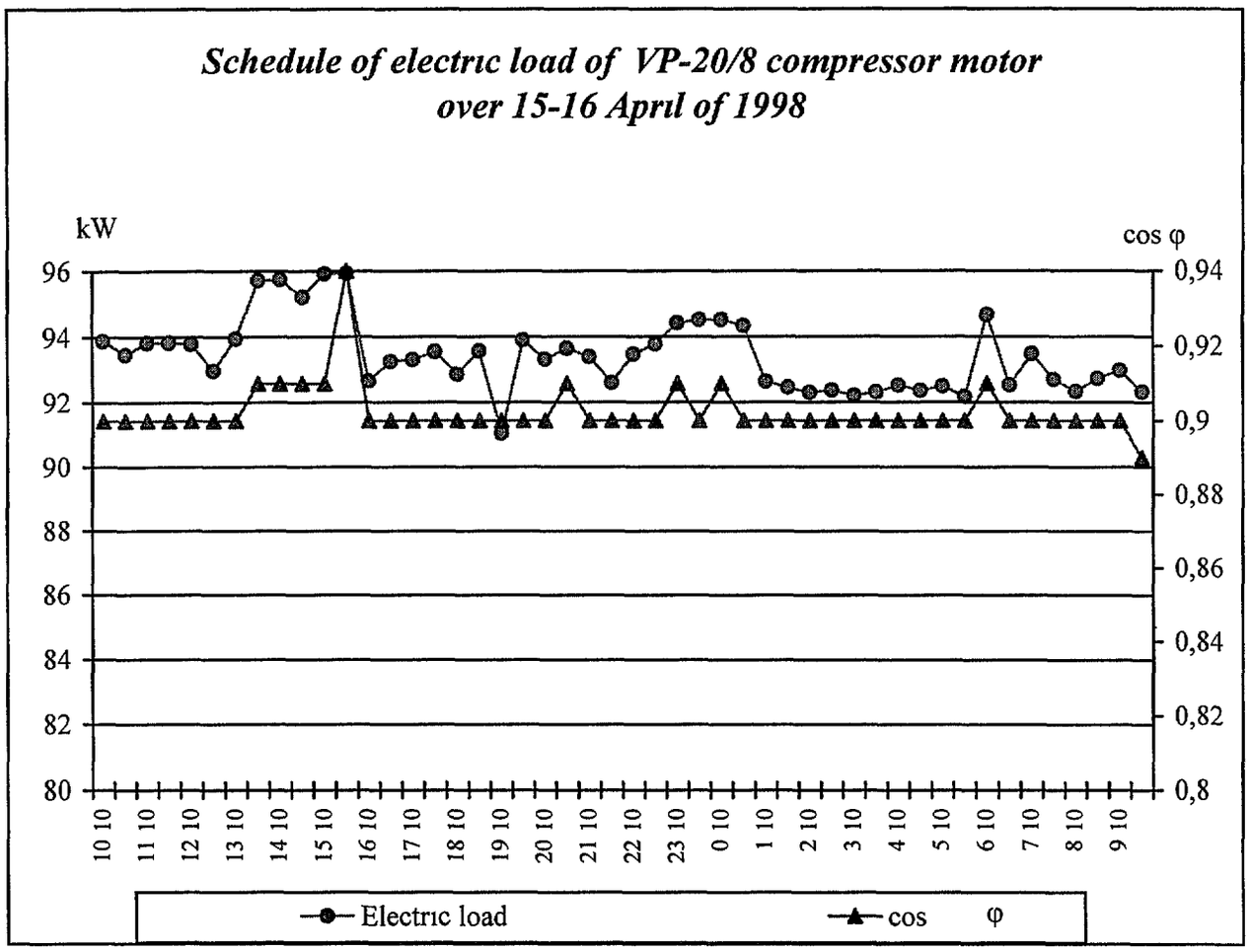
Compressed air for production purposes is supplied by two compressors
1 3SK-240 B1 - - 16 m^3/min capacity with 100 kW electric motor
2 VP-20/8 - 20 m^3/min capacity with 132 kW electric motor
Total capacity of compressors 16 + 20 = 36 (m^3/min)
Considering mechanical wear-out of the compressors the maximum capacity does not exceed 30 m^3/min

Consumption of compressed air by production lines (by the plant data)

Production unit	Diameter of supply compressed air pipeline, mm	Compressed air pressure, ATM
W/shop #1 - 6 m^3/,		
production units		
• cold rooms ##2,3,4	32	4
• weighing room of hydrochloric acid	15	4
• weighing room of glycoxal	20	4
• repair units of w/shop No1	20	4
• lime-slaking unit	25	4
No2 w/shop - 6 3 m^3/min,		
production units		
• header overhaul	15	4
• crimping	15	6
• mechanical shops	15	4
• frankfurter lines	15	4
• normal size drying lines	15	4
• maturing storage	15	4
• preparation of neutralizing solutions	15	4
Mechanical repair w/shop - 14 m^3/min		
production units		
• workshop	20	6
• shot-blasting	32	6
• bending plant	20	6
• mechanical scissors	20	6
• plasma cutting	20	6
• electric lift truck repair unit	32	6
Quality assurance office - 0 24 m^3/min		
• skin boiling laboratory	20	4
Electric supply and instrumentation w/shop - 1 33 m^3/min	— —	
• instrumentation w/shops	20	6
• electric equipment repair w/shops	20	6
Electric supply and plumbing w/shop-0 29m^3/min		
• w/shops	20	6
TOTAL 28 16 m^3/min		

Considering the length of piping and losses of compressed air during transportation as well as measurements of electric loads of compressors by the "DRANETZ" energy analyzer between 10 and 17 April 1998 actual consumption of compressed air for production purposes was significantly lower than in the information given by the plant





3SK-240 B1 compressor

The main capacity load is at 8°° to 17°° hours At this time the load varies within 60–85% of nominal capacity The rest of time the compressor runs at 40–50% of the capacity

VP-20/8 compressor

Average daily load on the compressor is 92–95 kW The maximum load on the motor does not exceed 110 kW

We recommend to install directly in the workshops instead of the existing compressor station small one-unit automatic compressor plants equipped with receivers and pressure relays that will reduce the electric power consumption by 50% and lower compressor operation and maintenance costs by 50% total value of which by preliminary estimates runs into 150,000$ per year

The energy auditors consider it necessary to install

- In workshops No1,2 - screw - type compressor plant consisting of two units operated both autonomously and in parallel
  Capacity of each unit is 5 78 m^3/min and 4 81 m^3/min
  Electric motor capacity is 37 and 30 kW (67 kW)
- In mechanical repair workshop - screw compressor plant, consisting of two units Capacity of each unit is 4 81 m^3/min and 3 26 m^3/min
  Electric motor capacity is 30 kW and 22 kW (52 kW)
- For the electric supply workshop and thermal supply and plumbing workshop and quality assurance office - one screw - type compressor plant with 2 08 m^3/capacity
  Electric motor capacity is 15 kW

Annual energy savings estimate

Hourly savings of electric power will be
150 x 0 5 ~ 75 (kW)
Annual savings of electric power will be
75 x 24 x 365 ~ 650,000 (kW)

Annual cost savings estimate

Cost savings by reduction of electricity consumption at the price of $0 038 per 1 kWh of electric power will be
650,000 x 0 038 ~ $25,000
Cost savings by reduction operation and maintenance cost will be
150,000 x 0 5 = $75,000
TOTAL cost savings will be
25,000 + 75,000 = $100,000

Implementation costs

10 6 m^3/min modular screw compressor unit - $31,000
8 07 m^3/min modular screw compressor unit compressor unit - $26,000
2 08 m^3/min screw compressor unit - $8,300
TOTAL - $65,300
Overheads 40% - $26,000
TOTAL costs - $91,300

Simple payback

Implementation costs - $91,300
Annual cost savings - $100,000
Simple payback period will be
91,300/100,000 ~ 0 9 year

A 11 ECO #11 REDUCTION OF ENERGY USE DURING REFRIGERATION EQUIPMENT OPERATION

ECO description

One of the primary electric energy users at the plant is an ammonia refrigeration compressor plant

The cooling consumers are as follows

- No 1 cold room - cold room for defrosting,
  area F = 580 m^2, equipped with 40 air coolers with of refrigeration generation capacity of Q_1 = 173 MCal/hour (201 2 kW)

- No 2 cold room - cold room for frankfurters,
  area F = 360 m^2, equipped with 16 air coolers with of refrigeration generation capacity of Q_2 = 40 Mcal/hour (46 5 kW)

- No 3 cold room - cold room for standard sausages,
  area F = 552 m^2, equipped with 24 air coolers with of refrigeration generation capacity of Q_3 = 77 Mcal/hour (89 5 kW)

- No 4 cold room - cold room for mixing lines,
  area F = 1,150 m^2, equipped with 64 air coolers with of refrigeration generation capacity of Q_4 = 200 Mcal/hour (232 6 kW)

Cold rooms are located in the main production building

on the first floor - cold rooms No 1, 2 and 3,
on the second floor - cold room No 4

Cooling consumption is even over the three-shift operation The collagen substance is cooled in the coolers by chilled water with +2^{0}C temperature The inside temperature is kept within 4^{0}C and 6^{0}C

The analysis performed by the energy audit team established that energy losses occur through the gaps in the doors and while the doors are open (2 x 3 m) During loading operations there is "spilling out" of cold air and its replacement with warm surrounding air through the open doors Due to production requirements every 15 min electric fork-lift trucks take in the products Plastic curtains are absent The doors are open for 1 minute causing overuse of cooling and power for its generation The measuremen5ts taken by infra-red non-contact thermometer and anemometer showed that the inside temperature was 6^{0}C and the outside temperature was 17-18^{0}C The experts of the European Commission of TACIS during visits to several Ukrainian plants in 1996 carried out various tests with the help of sensitive measuring devices and established energy losses through open doors (2 x 3 m) of cold rooms at various values of difference between inside and outside temperatures Using these data we can establish that at the relative humidity inside the cold rooms of 90% and temperature difference equal to 11^{0}C energy losses at the cold rooms is 20 kW

In order to reduce cooling generation costs the energy auditors recommend to install at the entrances to the cold rooms plastic curtains that will result in minimizing energy losses Introduction of this ECO will ensure reduction of cooling consumption and, accordingly, of electric power by 5 - 7%

Annual energy savings estimate

Annual consumption of electric power for refrigeration by the experts' estimate is 1,200,000 kWh

Estimated reduction of cooling consumption will be 5%

Electric power savings will be
S = 1,200,000 x 0 05 =60,000 (kWh)

Cost savings estimate

Cost savings at the price of electricity of $0 038 per 1 kWh will be
S_c = 60,000 x 0 038 = $2,280

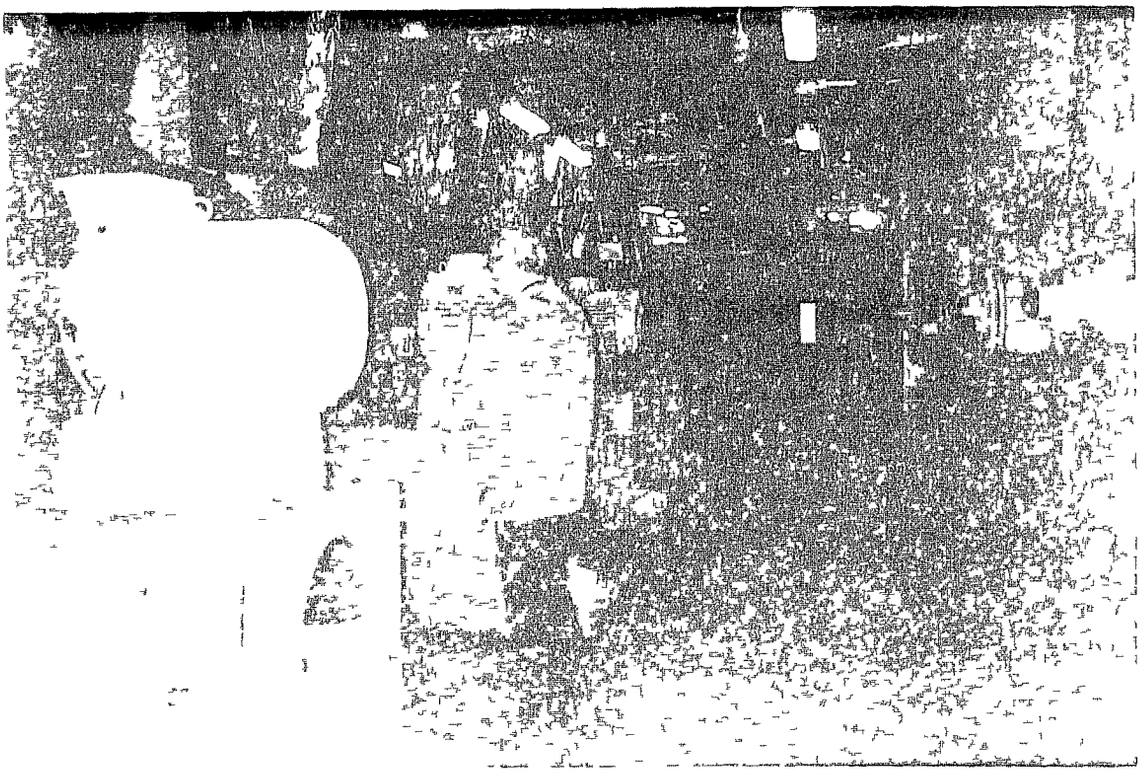
Implementation cost

Cost of plastic insulation curtains - 5 x $200 = $1,000

Simple payback

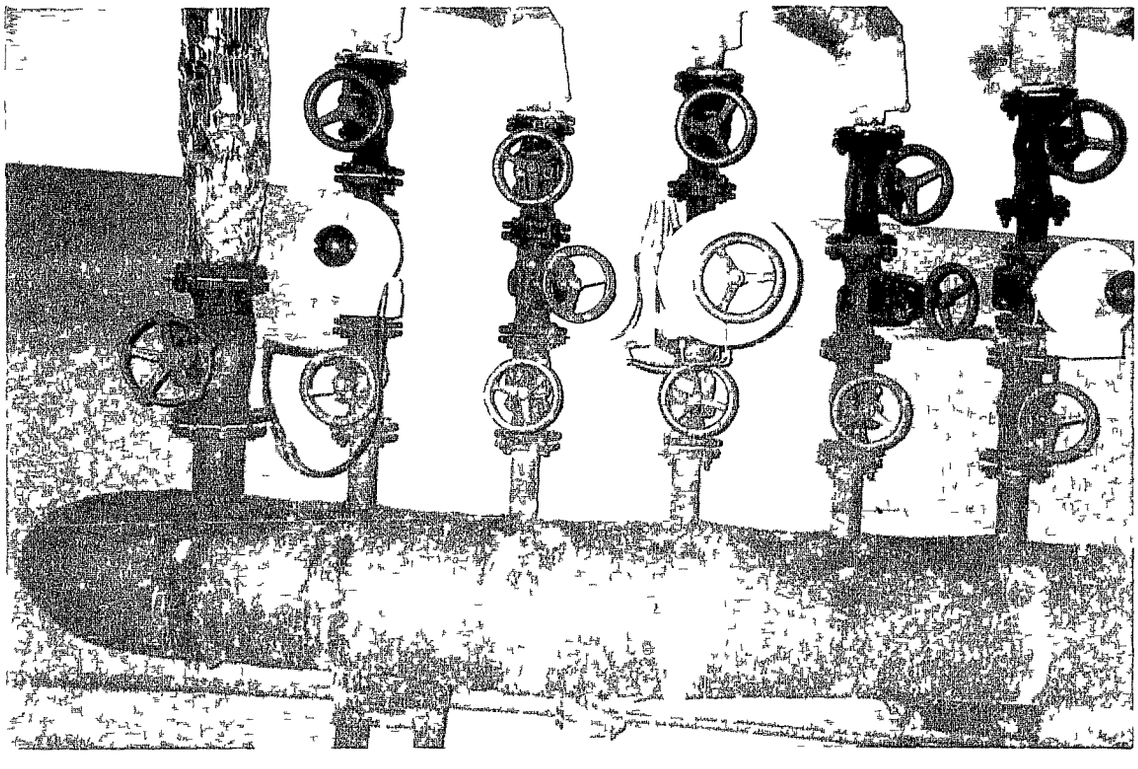
Implementation cost - $1,000
Annual cost savings - $2,280
Simple payback
1,000/2,280 = 0 4 (year)

APPENDIX B PHOROGRAPHS OF THE PLANT

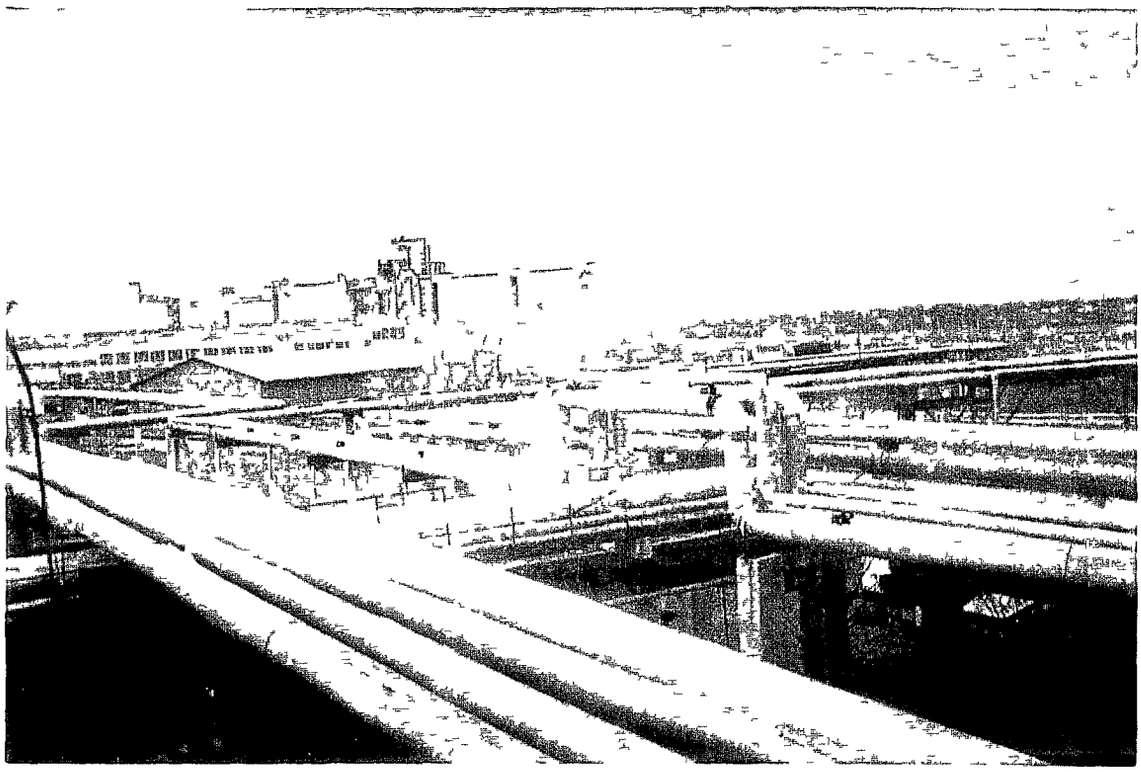


Зал воздухотехники

AIR SUPPLY UNIT



Производство измерений газоанализатором “ENERAC -2000” состава уходящих газов за котлом ДКВР-20-13”
Exhaust gas composition measurement by ENERAC-2000 combustion analyzer behind DKVR-20-13 boiler

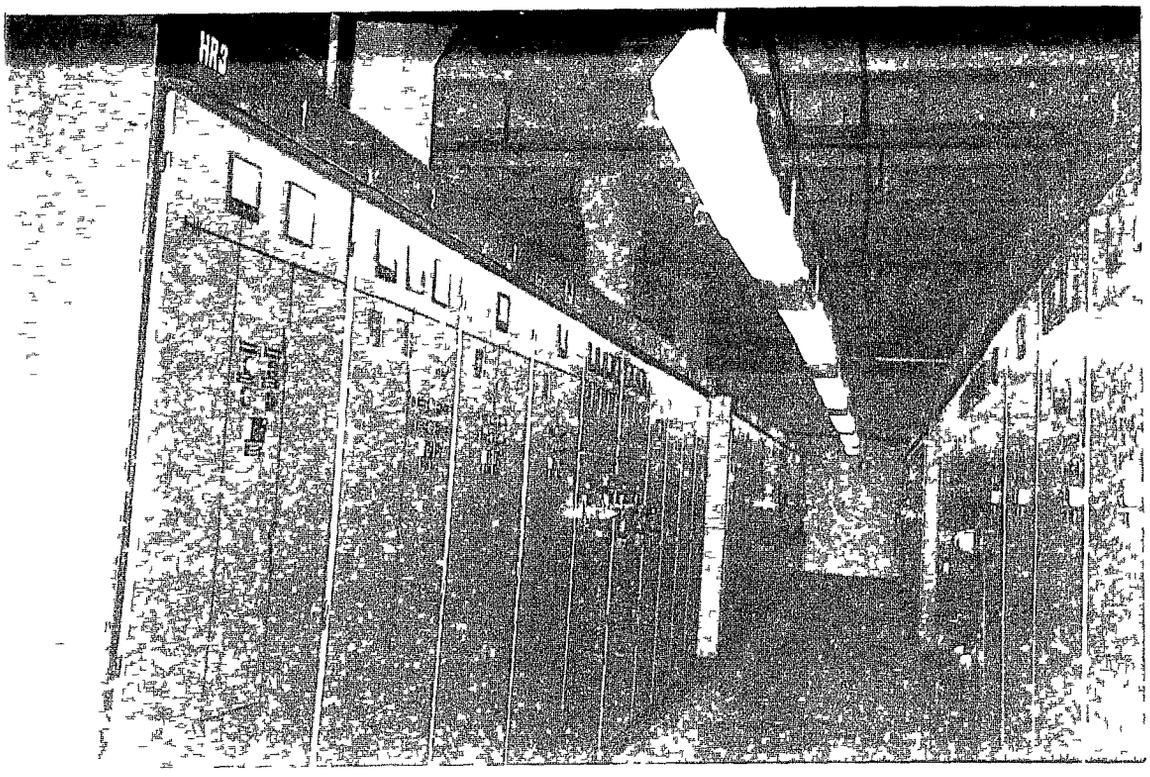


Тепловые сети завода “БЕЛКОЗИН”

Heat supply lines at BELKOZIN plant

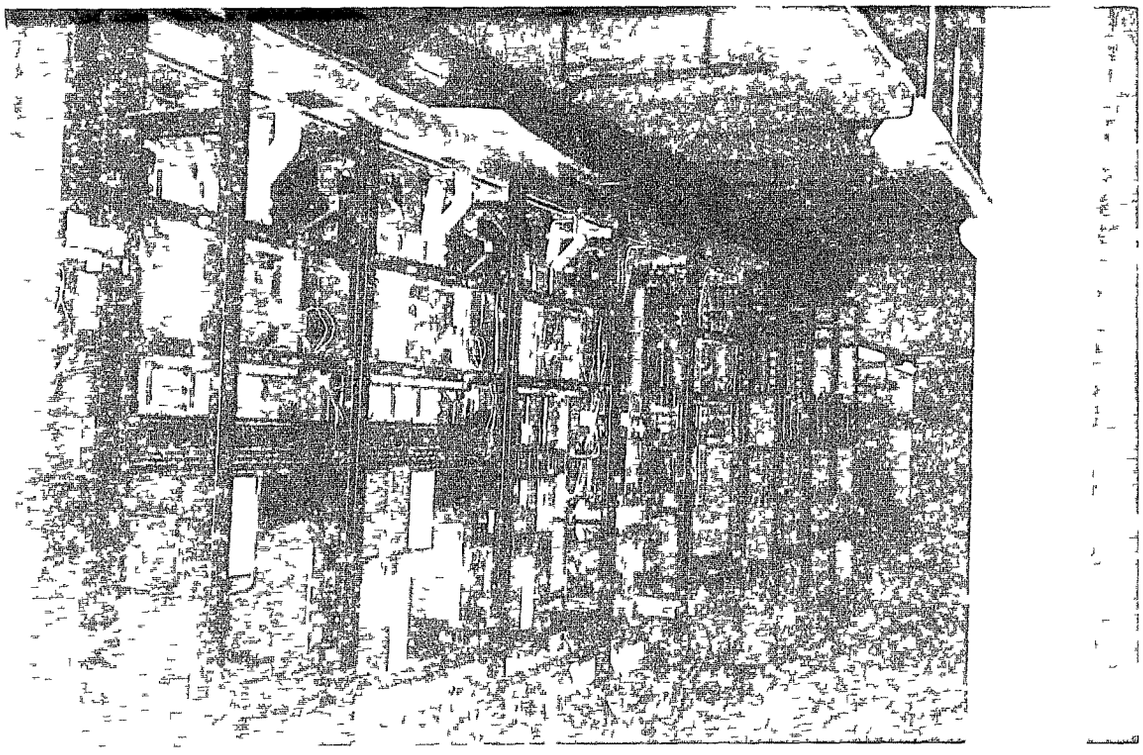
Холодильная компрессорная станция

Refriqerating compressor station



Распределительное устройство 0,4 кВ ТП - 1

0,4 kV TP-1 Distribution System



APPENDIX C 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
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
kgce - kg of coal equivalent
kgf - kilogram-force

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