PN-AUD-556
99373

Delivery Order #30
Industrial Energy Efficiency - Ukraine
March 1998

REPORT
ON ENERGY AUDIT
AT OPEN JOINT-STOCK COMPANY
"KYIV MEAT PROCESSING PLANT"
Kyiv City, UKRAINE

Prepared by Mr Valery Deineko
Mr Alexandr Silakin

Prepared for United States Agency for International Development,
Washington, D C 20523-1415

Burns and Roe Enterprises, Inc
1400 K Street NW Suite 1050 Washington, D C 20005
Telephone 202-408-6831 Facsimile 202-408-6835

c 1

Table of Contents

1 0 EXECUTIVE SUMMARY 3

1 1 INTRODUCTION 3
1 2 PRINCIPAL FINDINGS 3
1 3 RECOMMENDATIONS 4

2 0 GENERAL BACKGROUND 6

2 1 HISTORY OF PLANT 6
2 2 TYPES OF PRODUCTS 6
2 3 NUMBER OF EMPLOYEES 7
2 4 SIGNIFICANCE OF THE SECTOR TO ECONOMY 7

3 0 CURRENT STATUS OF PRODUCTION 8

3 1 MAXIMUM ESTIMATED PRODUCTION CAPACITY OF PLANT 8
3 2 REAL PRODUCTION CAPACITY OF PLANT 8
3 3 CURRENT TREND 9
3 4 EXPORT VS DOMESTIC PRODUCTION 9

4 0 FINANCIAL STATUS OF PLANT 10

4 1 CURRENCY VS BARTER 10
4 2 VIABILITY OF PLANT 10

5 0 ANNUAL ENERGY CONSUMPTION AND COSTS 11

5 1 BRIEF DESCRIPTION OF THE PROCESSING 11
5 2 BASIC ENERGY CONSUMING EQUIPMENT 11
5 3 CURRENT TARIFFS ON ELECTRIC POWER AND FUEL IN 1998 12
5 4 METERING CONSUMPTION OF ENERGY RESOURCES 13
5 5 STRUCTURE OF ENERGY CONSUMPTION AND ITS COST IN 1997 13
5 6 CONSUMPTION OF ELECTRIC POWER, NATURAL GAS, THERMAL ENERGY AND WATER IN 1997 16
5 6 1 Electric power (kW h x 10^3) *16*
5 6 2 Natural gas (m^3 x 10^3) *19*
5 6 3 Thermal energy (Gcal) *19*
5 6 4 Artificial cold *22*
5 6 5 Drinking water (m^3 x 1 000) *24*

6 O SPECIFIC ENERGY CONSUMPTION 27

6 1 SPECIFIC ENERGY CONSUMPTION PER 1 TONNE OF THE MAIN KINDS OF PRODUCTS FOR 1997 27
6 2 ANALYSIS OF THE PLANT OPERATION DURING MARCH 2 - 16 1998 32

7 0 PREVIOUS ENERGY IMPROVEMENTS 38

8 0 ENERGY CONSERVATION MEASURES 39

9 0 EFFECT OF IMPLEMENTING THE RECOMMENDATIONS 44

ON THE ENVIRONMENT 44

APPENDICES

A ENERGY CONSERVATION OPPORTUNITIES
B MEASURED AND COLLECTED DATA
C PHOTOGRAPHS OF THE PLANT
F CONVERSION FACTORS
E ABBREVIATIONS

1 0 EXECUTIVE SUMMARY

1 1 Introduction

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

These audits consisted of a one week site visit by a team of engineers, normally two or three individuals 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 However, 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 Principal Findings

A group of energy auditors between March 16 and 21 1998 performed an energy audit at the Open Joint-Stock Company "Kyiv Meat Processing Plant" (OJSC *"KMPZ"*)

The basic products at the OJSC *"KMPZ"* are sausages, the ancillary products are technical fat and bone meal The enterprise has two production grounds Production Ground #1 (Vyshnevy Town, Kyiv Region) and Production Ground #2 (Kyiv City)

In the period between 1995 and 1997 the production output of the basic products increased from 4,532 tonnes to 5,775 tonnes per year

The energy audit was performed at the basic enterprise (Production Ground #1) that produces about 75 per cent of the total production output

The enterprise has its own sources of thermal energy, cold supply, as well as basic and auxiliary services providing a completed production cycle

OJSC *"KMPZ"* is quite a large consumer of natural gas, electric power and water The cost of the energy resources bought in 1997 was about USD 1 1 million

In the process of the audit a lot of attractive opportunities to improve the energy efficiency at the plant by means of both short-term payback periods (up to 1 year) that do not require high costs, and middle-term payback periods (up to 2 years) requiring noticeable capital investments

Implementation of the proposed measures will result attainment the following savings

- saving of electric power - 1,055,000 kW h,
- saving of natural gas - 1,260,000 m^3,
- saving of water - 20,400 m^3

The energy costs saving is USD 158,540 per year, and the costs of the measures to be implemented being USD 183,010 At the same time there is achieved decreasing of emissions of harmful substances into the atmosphere (CO, SO_2, NO_x, ash) by 19 8 tonnes per year

Having arranged the ECOs projects for their implementations due to their priorities, while doing the financial estimations of the projects one has to take into consideration the interaction of these projects

At the same time the plant has got reserves for further energy saving implementation of which requires a more detailed study

1 3 Recommendations

The below table give a list of the energy conservation opportunities In the table there are given the data concerning energy conservation (ECOs), expected saving of the energy costs and the simple payback period of the proposed measures

To contribute to improvements of the energy efficiency at the plant and to decrease the energy costs, USAID will provide the plant equipment for performing energy audits This equipment will include portable devices and measuring instruments for energy audits The given energy saving opportunity is shown in the table as Energy Conservation Opportunity #1 **(ECO #1)** The point of the recommendation is to organize energy management departments that are to be responsible for the control, analysis of energy consumption at the enterprise and to bear responsibility for development recommendations aimed at redesigning or upgrading any systems if that can lead to energy saving

As a rule, an energy management service should consist of three persons a technical manager, electric engineer and thermal engineer The manager should be included into the plant management and report directly to the director of the plant It is very important, as the energy use issues become especially important, and the plant manager should be aware of all the potential opportunities capable of giving energy saving
The main directions in regard of energy saving that are recommended after the energy audit are as follows

- organization of automatic metering of energy resources consumption at the plant, which will allow to introduce at the plant a system for controlling and planning energy consumption (**ECO #2**),
- improvement of the efficiency of gas combustion in the boiler-house (ECOs **#3, 4 ,5**),
- improvement of the efficiency of the thermal energy (**ECOs #6, 7**),
- improvement the operation efficiency of the refrigerating and freezing chambers (**ECO #8**)

ECOs with a short payback period (**ECOs # 1, 3, 5, 8,**) are recommended for their implementation in the first order When more finances are available, the plant management should consider the issue of implementing the other opportunities (**ECOs # 2, 4, 6 and 7**)
It seems reasonable to carry out an energy audit at Production #2 (Kyiv City) whose share in the output of the *KMPP* is 25 per cent

List of Energy Conservation Opportunities (ECOs)

ECOs	Description	Saving					Cost of the saved energy (US $)	Project costs (US $)	Payback period (year)
		Electric power (1,000 kW h)	Natural gas (1,000 m³)	Steam (Gcal)	Hot water (1,000 m³)	Cold water (1,000 m³)			
1	Introduction of energy management program	488	360			12	49,960	48,980	1 0
2	Automatic systems for energy consumption metering	293	216				29,570	49,500	1 7
3	Optimization of gas combustion in steam boilers		108				9,360	7,000	0 75
4	Automatic control of the burning process and of the low pressure in the furnace of *DKVR-10/13* boiler	46	202				19,170	21,700	1 13
5	Redesigning of *DKVR-6 5/13* boiler for water heating operation mode	16	195				17,512	16,500	0 94
6	Steam traps		120				10,440	15,860	1 5
7	Steam and water mixing stations		62			8 4	14,670	16,640	1 14
8	Control of the temperature mode in the refrigerating and freezing chambers	212					7,860	6,830	0 9
	Total	**1,055**	**1,263**			**20 4**	**158,542**	**183,010**	**1 2**

2 0 GENERAL BACKGROUND

Director General — Mr Volodymyr Stepanovych HAK
Deputy Director on Energy — Mr Arkady Isaakovych ZASLAVSKY

Tel [380-44]- 489-08-88
Fax [380-44]- 474-16-44

Kyiv Meat Processing Plant #3,
9, Promyslova Str ,
Vyshnevy Town, Kyiv Region,
255500, Ukraine

2 1 History of Plant

OJSC *"Kyiv Meat Processing Plant"* was commissioned in 1976 The basic profile of activities is production of sausage and meat products In 1996 the plant was transformed into an open joint-stock company with a collective form of the property The basic production areas at the plant are the following ones

- a cooler
- raw materials workshop
- sausage making workshop
- fat making workshop
- cool-production and compressor workshop
- steam-production and boiler workshop
- electric power production workshop, electric metering instruments area
- repair and maintenance workshop
- repair and construction workshop
- laundry workshop
- other plant units

2 2 Types of products

The plant produces and deliver sausage products for the trade system in the city of Kyiv and other places in Ukraine cooked sausages, smoked sausages, summer sausages, balyks (cured fillet of sturgeon, etc), hams, brisket and bacon, sausages and frankfurters, etc The regions of Ukraine are supplied with technical fats, bone meal, etc

At the plant there is in progress upgrading of the production lines aimed at widening the assortment of the finished products in the packages for a long-term saving them

The plant has a set of specialized shops

The plant supplies thermal energy (6-barg steam) and artificial cool (minus 12-degree centigrade ammonia) for the Open Joint-Stock Company *"Kyiv City Dairy Plant #3"* The plant sells 55 per cent of the total amount of the produced thermal energy and 59 per cent of the total amount of the produced cold energy

The plant did not provide any data concerning the cost of the sold energy and the profits received So, when estimating the costs saving after implementation of the ECOs this factor was not taken into consideration

2 3 Number of employees

On March 16, 1998 the average number of the employees at the plant was about 500 persons

2 4 Significance of the sector to economy

There are plants of the similar profile in all regions of Ukraine Their total number is about 500, including 9 large meat processing plant producing meat products and sausages The improvement of energy use efficiency in this branch and in the food industry is very important for the population and economy of Ukraine

3 0 CURRENT STATUS OF PRODUCTION

3 1 Maximum estimated production capacity of plant

The maximum production capacity of the plant is as follows

sausage products - 45 tonnes per day
meat semi-finished products - 5 tonnes per day

3 2 Real production capacity of plant

In 1995 - 1997 the plant operated not in its full capacity as the sale market was reduced The highest decline happened in 1996 In 1997 the average output of the produced products was 16 4 tonnes per day

It is possible for the enterprise to increase the production level to the designed value if the market demand increases

The production levels

Table 1

Products	Production level, tonne			Note
	1995	1996	1997	
1 Sausage products	4,532	3,421	4,267	Production Ground #1

Production levels for the basic products in 1997

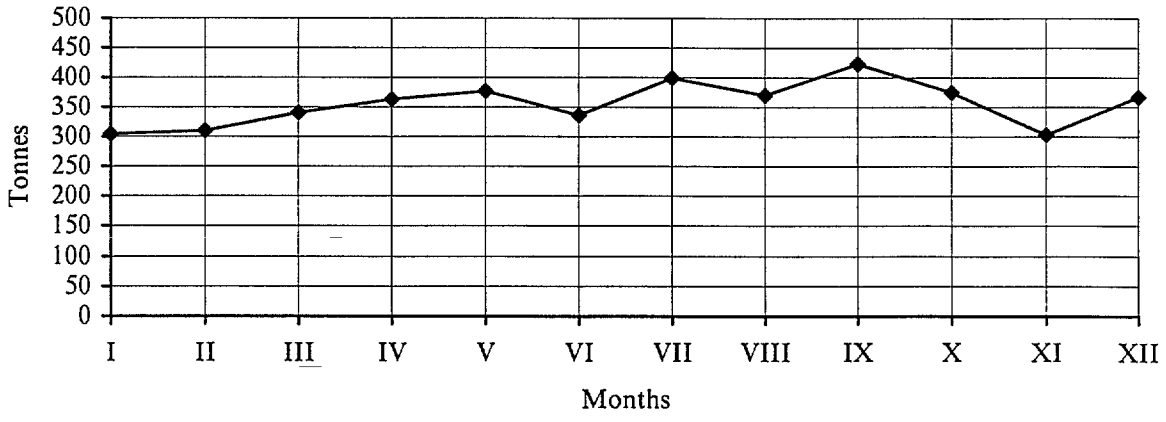


Fig 1

3 3 Current Trend

The management of the plant makes all possible efforts to improve the competitiveness of the products of the plant by improving their quality, enlarging their assortment and decreasing their net cost There is planned to increase the production level to 19 - 20 tonnes per working day The basic production area operates 5 days a week during 8 hours per day

3 4 Export vs Domestic production

According to the data for 1997, no export operations were performed by the OJSC *"Kyiv Meat Processing Plant"*

4 0 FINANCIAL STATUS OF PLANT

4 1 Currency vs Barter

There were no bartering operations at the plant in 1997

4 2 Viability of plant

The enterprise is profitable, it has no indebtedness in regard of paying for the energy resources

5 0 ANNUAL ENERGY CONSUMPTION AND COSTS

5 1 Brief description of the processing

The processing of basic sorts of products includes the following operations

- Freezing, keeping the frozen raw materials (–25 to –12^{0}C)
- Keeping the frozen raw materials (0 to +2^{0}C)
- Defrostration of the frozen raw materials (0 to +2^{0}C)
- Preparation of raw materials (+12^{0}C)
- Disintegration (+2 to +4^{0}C)
- Salting (+2 to +4^{0}C)
- Maturing (+2^{0}C)
- Farce preparation (+12^{0}C)
- Filling with farce (+12^{0}C)
- Thermal treatment (drying, firing, boiling, smoking, cooling)
- Keeping (+2 – +4^{0}C)
- Packaging

A special feature about the meat processing is use of different energy sources and kinds of energy electric power, natural gas, thermal energy (steam and hot water), artificial ice, compressed air and water

5 2 Basic energy consuming equipment

Electric power

1	Compressors for ammonia coolers	N = 132 kW	— 25 units
2	Circulation water supply pumps	N = 37 kW	— 8 units
3	Ammonia pumping pumps	N = 13 kW	— 8 units
4	Processing equipment		
	• Meat cutters	N = 22 kW	— 8 units
	• Cutters	N = 180 kW	— 6 units
	• Breakers and crushers	N = 55 kW	— 4 units
	• Farce mixers	N = 30 kW	— 6 units
	• Farce filling machines	N = 5 kW	— 10 units
	• Thermal aggregates	N = 15 kW	— 24 units
	• Black houses	N = up to 3 kW	— 8 units
	• Smoke aggregates	N = 2 2 kW	— 12 units
5	Conditioning and ventilation systems		
	• Central conditioners	N = 30 kW	— 5 units
	• Inlet and outlet fans	N = 5 5 to 7 5 kW	— 15 units
	• Outlet fans, window-type	N = 0 55 kW	— 25 units
6	Ancillary mechanisms transporting lines, elevators, telphers		
7	Freight elevators	N = 20 kW	— 7 units
8	Electric equipment for the boiler-house (exhaust fans, ventilators, pumps)		
9	Air compressors	N = 75 kW	— 3 units

Thermal energy

1 Steam

1 1	*OKhKI 286/VP*-type plants for meat products thermal treatment	— 24 units
1 2	Black houses	— 8 units
1 3	Cookers	— 6 units
1 4	Defrostator calorifers	— 5 units
1 5	Autoclaves	— 6 units
1 6	Vacuum boilers	— 3 items
1 7	Washing machines	— 3 units
1 8	Settling tanks (4 items), fat collectors (3 units)	
1 9	Washing and drying machines	— 9 units

2 Hot delivery water, 95 to 70°C

2 1 Radiation heaters
2 2 Air heaters

3 Hot water supply

3 1 Processing needs
3 2 Washing of equipment, walls, floors
3 3 Everyday and utility needs

4 Refrigeration

4 1 "Icy water" as the coolant (0 5 to 1°C)
- conditioning systems

4 2 Ammonia as the coolant (– 12°C)
- coolers and processing chambers
- defrosters
- "icy water" heat exchangers

4 3 Ammonia as the coolant (– 25°C)
- freezers

5 Natural gas

5 1	*DKVR - 6 5 / 13* steam boilers with the steam production capacity of 6 5 t/h	— 3 units
5 2	*DKVR - 10 / 13* steam boilers with the steam production capacity of 10 t/h	— 1 units

5 3 Current tariffs on electric power and fuel in 1998

1,000 m^3 of natural gas costs	—	US $86 7 (without VAT)
1 kW h of electric power costs	—	US $0 037
1 m^3 of drinking water costs	—	US $0 575 (without VAT)
1 m^3 of sewage costs	—	US $0 535 (without VAT)

5 4 Metering consumption of energy resources

Commercial metering of consumption of the natural gas supplied to the plant was done by means of a processor-based system *"SuperFlo"* including a narrowing device

Commercial metering of electric power consumption was performed by means of active and reactive power meters used in the high-voltage circuit on the input transformer substations

Commercial metering of water consumption was performed by means of mechanical water consumption meters set on the inlet pipe ducts

The daily readings of the meters and flow meters are entered into register books , and at the end of each month the bills are issued to be paid on the basis of these data

Metering of the consumption within the territory of the plant of electric power, thermal energy, artificial cold and water is determined by calculation on the basis of the plant specific consumption rates

5 5 Structure of energy consumption and its cost in 1997

OJSC *"Kyiv Meat Processing Plant"* uses for its processing needs electric power, natural gas and drinking water In 1997 there was consumed about 9 8 million kW h of electric power that cost US $360,000, about 7 2 million m^3 of natural gas that cost US $628,000, about 236,000 m^3 that cost US $136,000

At the same time the plant is a supplier of thermal energy and artificial cold to the OJSC *"Kyiv City Dairy Plant #3"* The amount of the heat and cold sold aside in 1997 was correspondingly 55 and 59 per cent

The structure of energy consumption and its costs is shown in Tables 2 and 3 and in Fig 2 to 5 The costs on the energy resources for the needs of the plant itself were respectively as follows natural gas – 46 per cent, electric power – 32 per cent, water – 22 percent of the total energy costs The plant should look for energy saving opportunities in improvement of efficiency of the electric equipment operation, of efficiency of gas burning and thermal energy use, reduction of water consumption There is reasonable making a detailed audit concerning each sort of energy resources with preparing a balance sheet of using energy by all basic production areas and processes aiming at understanding how efficiently energy resources are used and at introduction of an objective system for controlling and planning the costs per one product unit

Table 2

The structure of the total energy use and its costs with taking into account the amounts of the sold thermal energy and artificial cold

Energy resource	Consumption	Gcal	Percentage	Cost, USD	Percentage
Natural gas	7,196,000 m^3	57,568	87	628,211	56
Electric power	9,755,000 kW h	8,389	13	360,935	32
Water	236,000 m^3	—	—	136,000	12
Total	—	65,957	100	1,126,081	100

Energy Balance

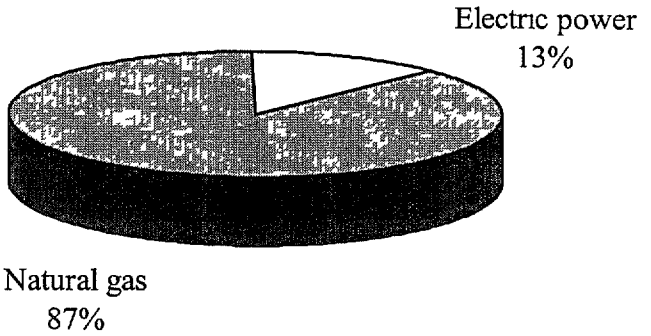


Fig 2

Balance of costs

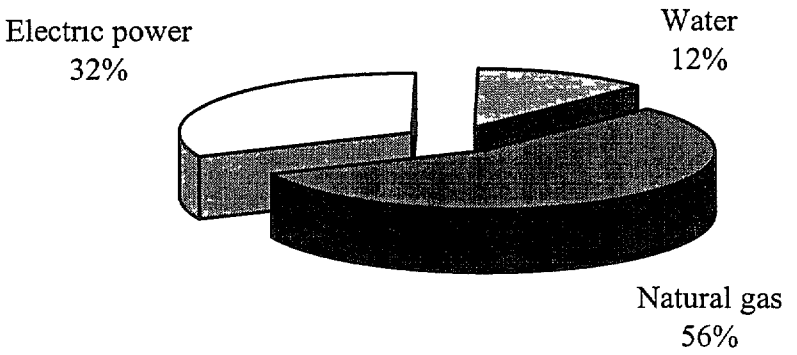


Fig 3

As the plant sells thermal energy and artificial cold aside, it does not seem possible to make an analysis of energy consumption per product of the basic sorts of the products produced That is why in the report we consider the energy costs for the production needs at the plant itself

The structure of the energy consumption for the needs of the plant itself

Table 3

Energy	Consumption	Gcal	Percentage	Cost, USD	Percentage
Natural gas	3,238,000 m^3	25,904	85	280,735	46
Electric power	5,272,000 kW h	4,534	15	195,064	32
Water	236,000 m^3	—	—	136,000	22
Total	—	30,438	100	611,799	100

Energy Balance

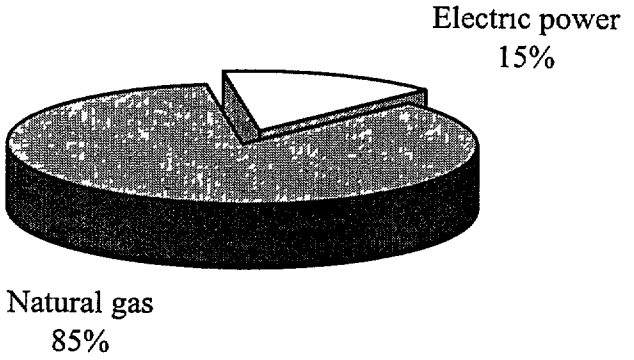


Fig 4

Balance of costs

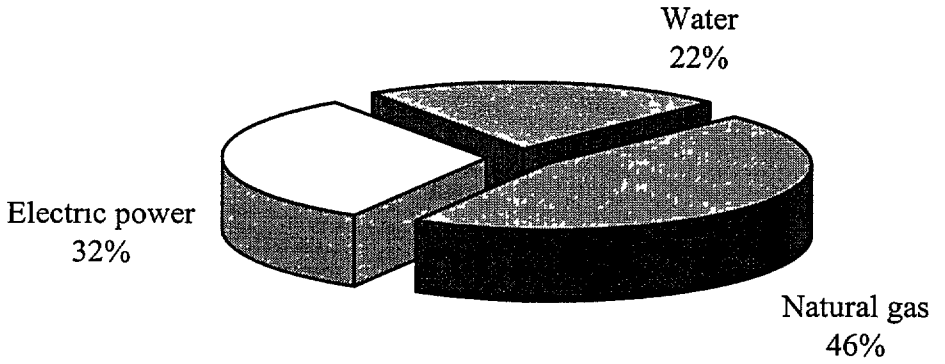


Fig 5

Note Data for calculations

1,000 m^3 = 8 1 Gcal 1,000 m^3 of natural gas — US $ 86,7
1,000 kW h = 0 86 Gcal 1,000 kW h — US $ 37
1,000 m^3 of water — US $ 575

As it follows from the balance of the costs, use of all sorts of energy sources requires a more detailed analysis to identify and estimate the energy conservation opportunities and to determine the attained base indicators for a specific energy consumption per product unit

5 6 Consumption of electric power, natural gas, thermal energy and water in 1997

5 6 1 Electric power, (kWh x 10^3)

Table 4

Months												
I	**II**	**III**	**IV**	**V**	**VI**	**VII**	**VIII**	**IX**	**X**	**XI**	**XII**	**Total**
Total consumption												
532	602	606	630	710	1,112	1,082	1,173	1,117	748	705	738	**9,755**
Cold production												
334	454	507	471	607	863	991	1,012	850	588	541	531	**7,749**
Boiler-house												
50 2	51 9	47 7	49 4	37 4	38 6	39 7	36 7	41 0	44 6	51 0	59 5	**547 7**
Compressor station												
2 0	4 0	4 0	14 8	13 8	34 2	10 0	7 3	15 5	14 6	17 5	15 0	**152 7**
Sausage making workshop												
70 1	56 7	20 9	58 5	17 0	113 8	25 2	48 8	121	63 1	51 1	63 8	**898 1**
Raw materials workshop												
10 5	8 4	9 8	13 3	6 5	14 8	1 5	6 3	13 6	12 9	12 1	15 0	**124 7**
Other users												
65 2	27	16 6	23	28 3	47 6	14 6	61 9	75 9	10 2	32 3	53 7	**282 8**

Consumption of electric power has a seasonal character, in summer it rises almost 2 times This is accounted for by rising of demand for artificial cold and decreasing of the efficiency of operation of the cold supplying system in the summer period of the year

The amount of the electric power consumed for cold production reaches 79 per cent of the total amount consumed during a year, which causes introduction of a good monitoring of the cold supply system and looking for energy saving reserves

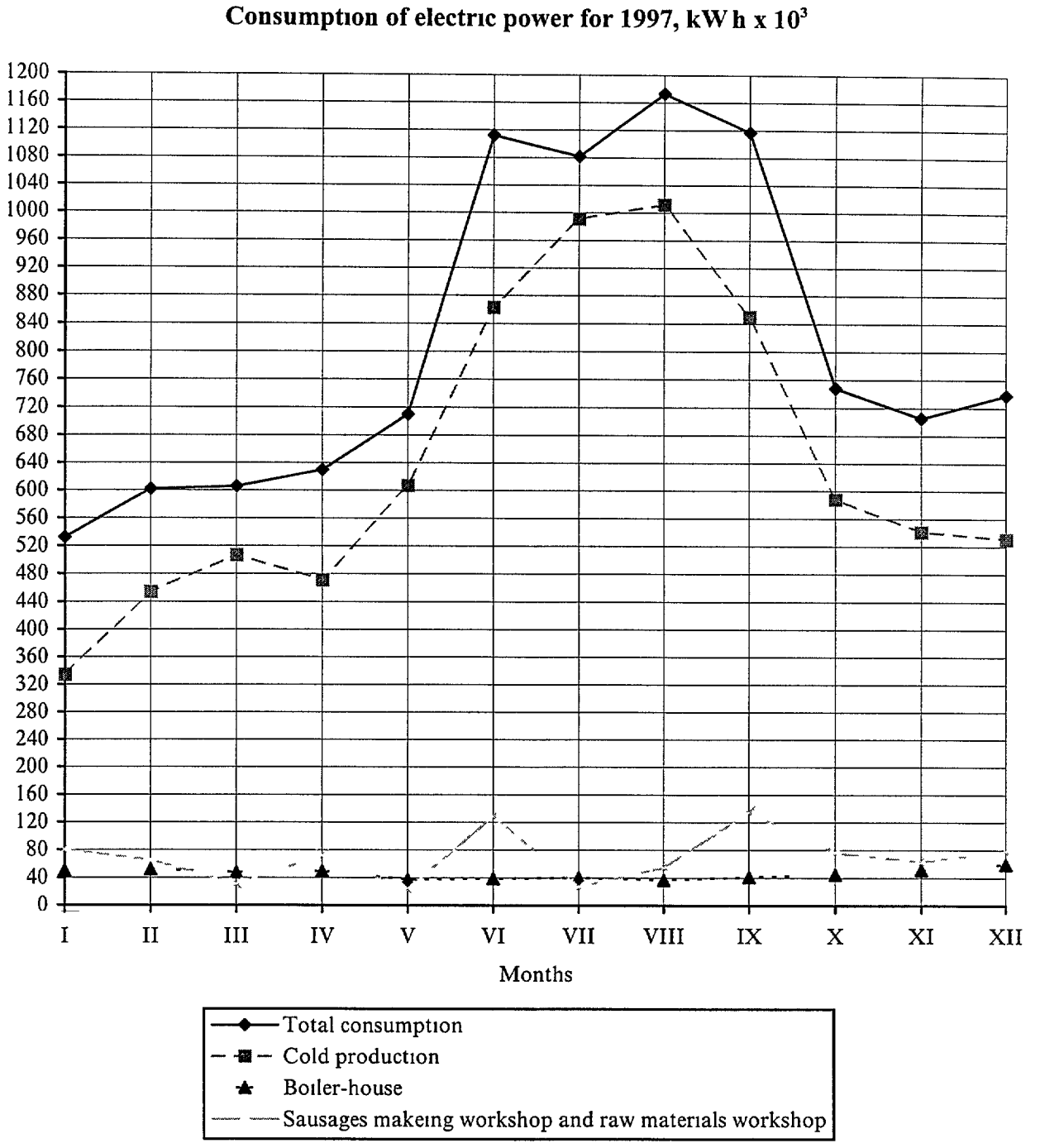

Consumption of electric power for 1997, kW h x 10³
1200
1160
1120
1080
1040
1000
960
920
880
840
800
760
720
680
640
600
560
520
480
440
400
360
320
280
240
200
160
120
80
40
0
I
II
III
IV
V
VI
VII
VIII
IX
X
XI
XII
Months
Total consumption
Cold production
Boiler-house
Sausages makeing workshop and raw materials workshop

Fig 6

Distribution of electric power consumption between the basic plant units with taking consideration the amount of the thermal energy and artificial cold sold aside

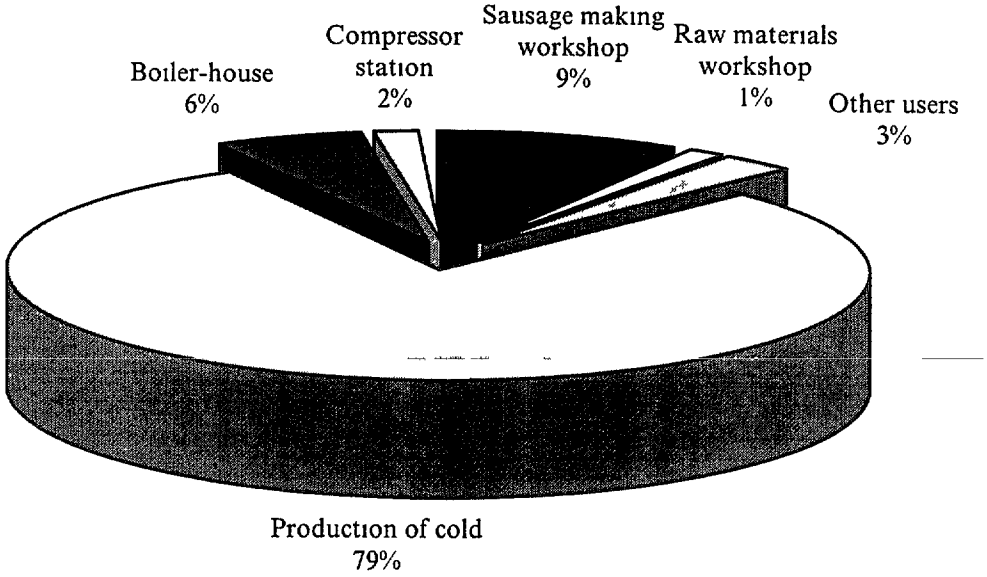


Fig 7

Distribution of electric power consumption between the basic plant areas and workshops

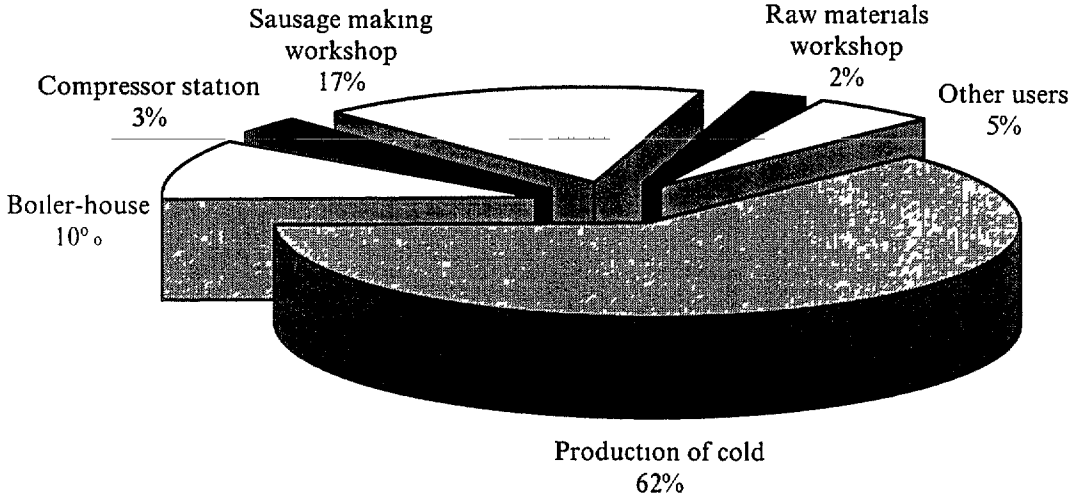


Fig 8

5 6 2 Natural gas, (m^3x 10^3)

Table 5

Months												
I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Total
Boiler-house												
826	690	700	619	469	477	486	458	500	613	630	728	**7,196**

Consumption of natural gas by the boiler-house, cu m x 1,000

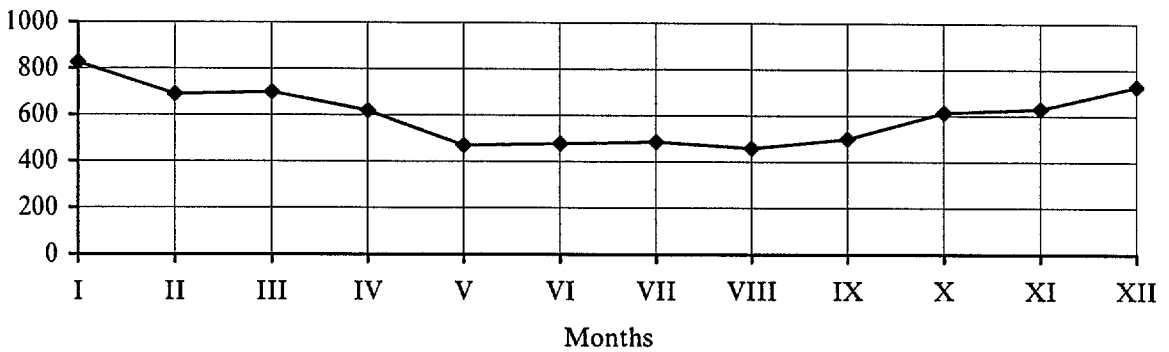


Fig 9

The amount of the natural gas consumed changes during a year and it has a seasonal character Gas is burnt in the boiler-house to produce steam that is used for the processing needs, to heat water for the hot water supply system, and for the heating system The heating load rises in winter, and it requires about 1 2 million m^3 of gas or about 14 per cent of the total consumption at the plant

5 6 3 Thermal energy, (Gcal)

Table 6

Months												
I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Total
Total production (calculations)												
5,451	4,670	4,750	4,200	3,208	3,287	3,391	3,196	3,493	4,130	4,252	4,960	**48,988**
Sold aside												
3,041	2,375	2,425	2,129	1,690	2,035	1,970	2,033	1,859	2,255	2,433	2,767	**27,012**
Consumption on the site												
2,410	2,295	2,325	2,071	1,518	1,252	1,421	1,163	1,634	1,875	1,819	2,193	**21,976**
Sausage making and raw materials workshops												
860	785	850	912	972	850	1,118	702	1,006	895	637	929	**10,516**
Fat making workshop												
380	420	475	369	95	222	113	242	260	23	48	65	**2,712**
Hot water supply												
180	180	180	180	451	180	190	219	272	272	300	300	**2,884**
Heating												
990	910	820	610	—	—	—	—	—	556	678	737	**5,301**

Months												
I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Total
Other users												
—	—	—	—	—	—	—	—	96	129	156	162	543

The amount of the thermal energy produced at the plant is determined approximately by calculation on the basis of the amount of the burnt natural gas that was supplied to the boiler-house On the ground of the data for the previously carried out tests of the boilers the specific gas consumption set for the plant is 147 m^3 for providing 1 Gcal of heat, which corresponds to the net efficiency of the boiler-house equal to 85 per cent and to the calorific value equal to 8,000 $kCal/m^3$

Production and consumption of thermal energy for 1997, Gcal

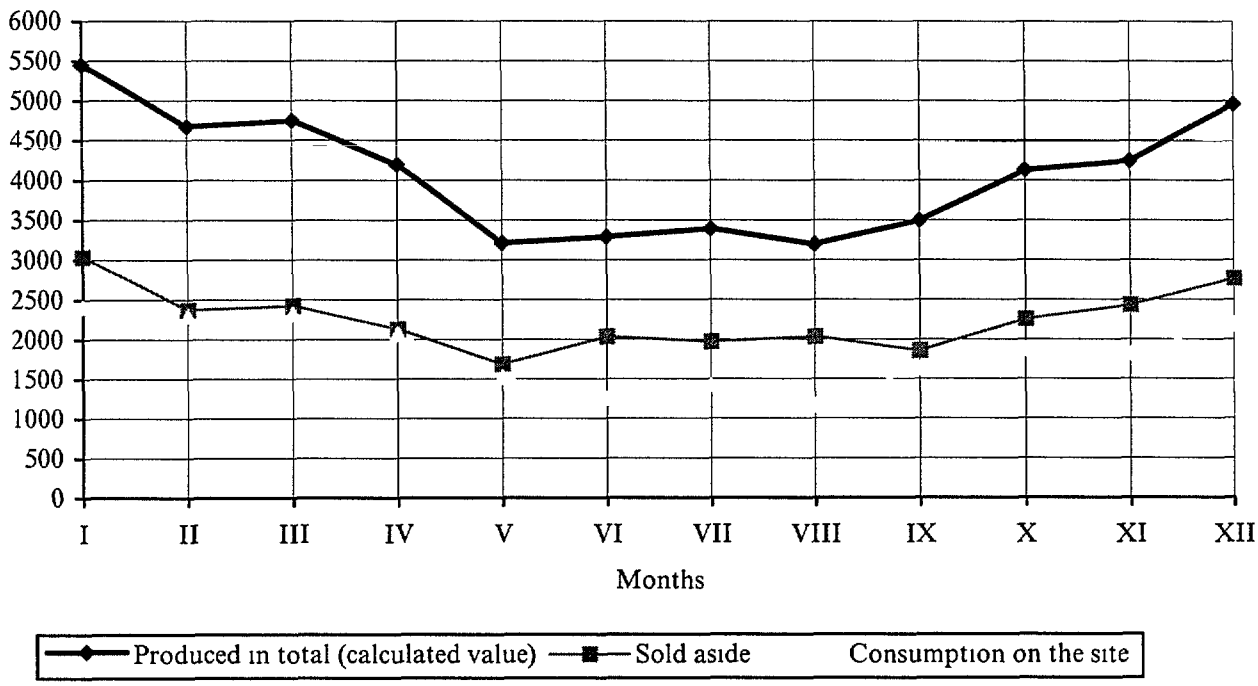


Fig 10

Distribution of the produced thermal energy

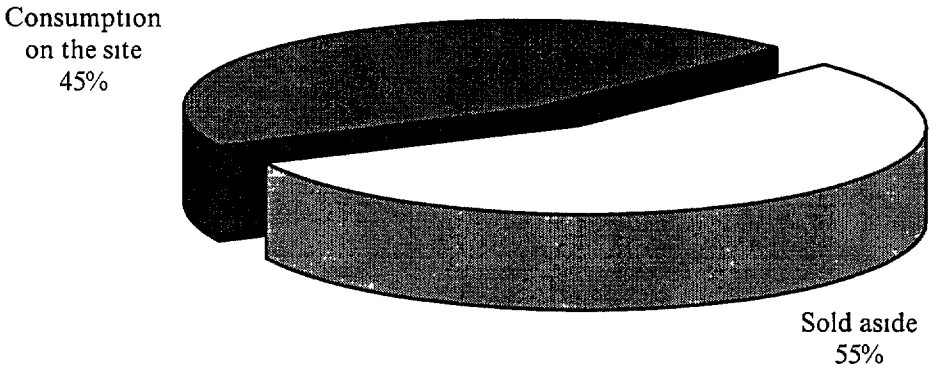


Fig 11

The production level of thermal energy during a year has a seasonal character and it is determined by the heating load available, the processing needs and by the amount sold aside
The consumption on the site for 1997 was 45 per cent, while there was sold aside 55 per cent of the energy amount totally produced

Distribution of thermal energy consumption between the basic plant structural units

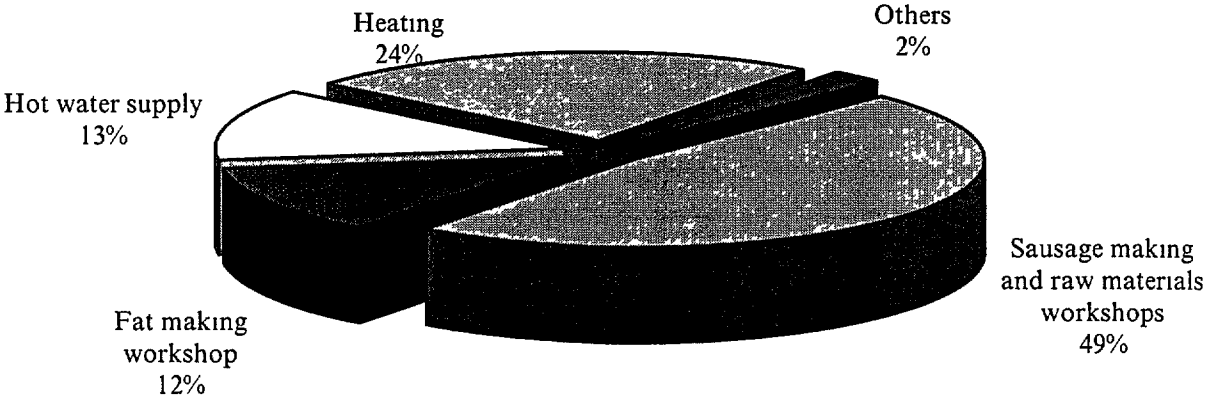


Fig 12

As it follows from the data received for the balance of distribution of the thermal energy in 1997, the main trends in energy saving should be improvement of the efficiency of the processing equipment (thermal chambers, cooking boilers, autoclaves, defrosters, hot water and heat supply systems, such as steam and water heaters, calorifers, ventilation and heating aggregates)

The data given by the plant do not completely correspond to the real situation and required to be corrected, as they do not take into consideration the losses with the condensate that was not returned, and the losses with the flash steam According to the calculations made in the steam and condensate report of the plant for 1996 the losses are 8 5 per cent of the total consumption of thermal energy

5 6 4 Artificial cold

Table 7

Months												
I	**II**	**III**	**IV**	**V**	**VI**	**VII**	**VIII**	**IX**	**X**	**XI**	**XII**	**Total**
Totally produced (calculated value)												
1,068	1,043	1,277	1,397	1,676	2,038	2,275	2,041	1,804	1,575	1,334	1,133	**18,661**
Sold aside												
558	570	764	855	1,112	1,295	1,265	1,120	1,015	925	811	652	**10,942**
Consumption on the site												
510	473	513	542	564	743	1,010	921	789	650	523	481	**7,719**
Cooler												
243	248	290	302	294	332	425	397	419	412	286	245	**3,893**
Sausage making and raw materials workshop												
211	223	222	206	236	378	552	489	357	231	229	231	**3,565**
Other users												
56	2	1	34	34	33	33	35	13	7	8	5	**261**

The amount of the produced artificial cold is determined at the plant approximately by calculation on the basis of the number of operation hours and of the average cold production capacity of the cooling machines according to their manufacturers specifications (326 to 358 thousand kcal/h) Distribution of cold between the plant structural units is also determined by calculation on the basis of the specific consumption rates set at the plant

- production of sausage products — 0 98 Gcal/t
- raw materials workshop — 0 44 Gcal/t
- keeping meat in refrigerators — 0 35 Gcal/t day

There was no complete audit for the refrigerating system to assess the efficiency of the cooling machines and of the cooling chamber

Taking into account the fact that, in accordance with the energy consumption balance cold production requires 79 per cent of electric power and 22 per cent of water, the plant management should invited a consulting company for that to carry out a detailed energy audit of the refrigerating system and to work out energy saving opportunities

Production and consumption of artificial cold

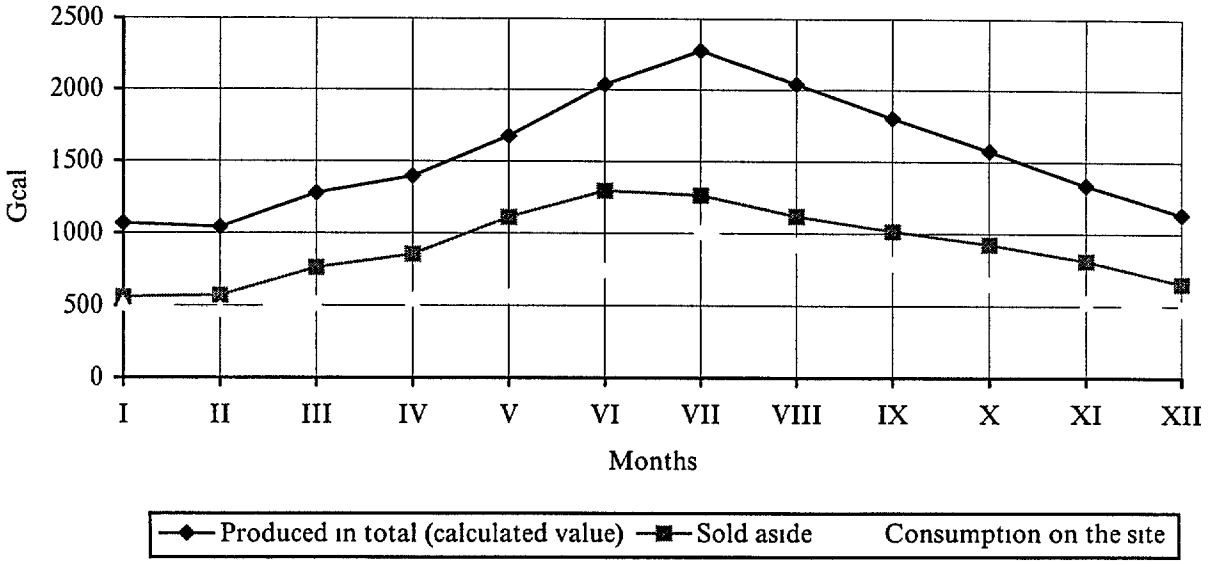


Fig 13

Distribution of the artificial cols produced

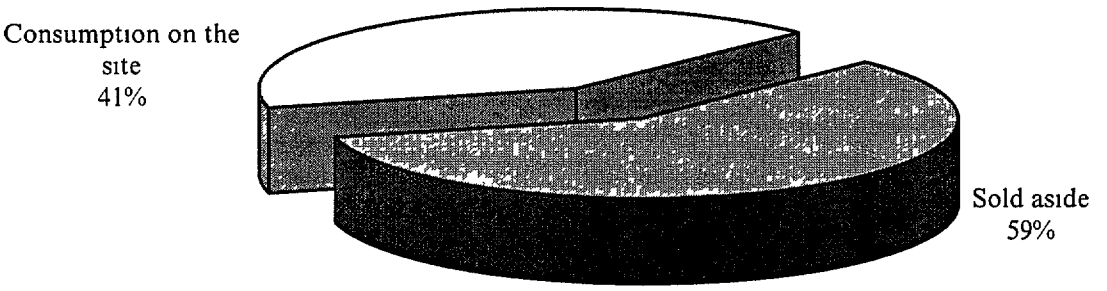


Fig 14

The amount of the produced cold during a year has a seasonal character In summer the need for cold rises 1 5 to 2 times both for the consumption on the site, and for its sale aside

Distribution of artificial cold consumption between the plant basic structural units

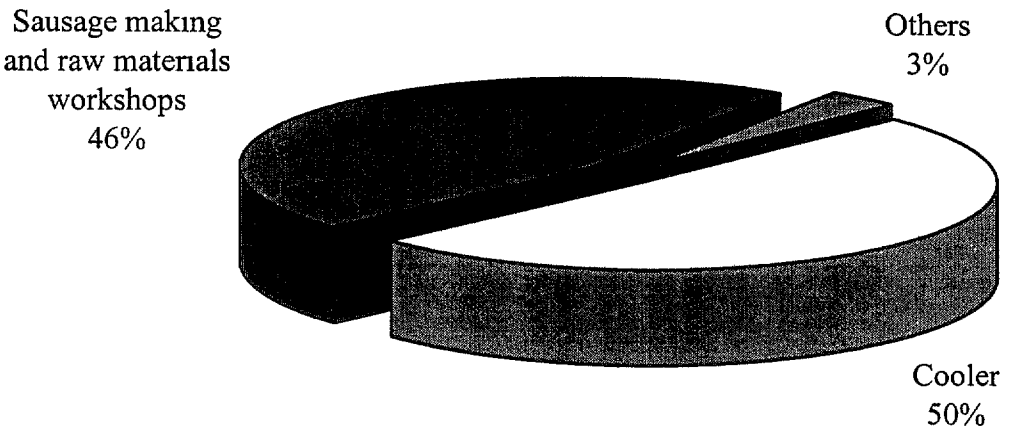


Fig 15

One of the main trends in energy saving is improvement of the efficiency of the artificial ice consumption in the sausage making and raw materials workshops as well as in the cooler The data represented by the plant do not completely correspond to the real situation, as there is not taken into account the losses of the coolant (ammonia, "icy " water) in the pipe lines of the coolant supply system

5 6 5 Drinking water, (m^3 x 1,000)

Table 8

Months												
I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Total
Total consumption												
17 7	17 6	18 5	21 5	19 0	21 3	21 5	20 8	21 7	19 6	18 6	18 5	**236 3**
Processing												
2 6	2 7	2 4	2 9	2 8	2 9	2 7	3 9	4,0	3 5	2 1	2 3	**34 8**
Artificial cold produced												
2 4	2 4	3 2	4 4	3 4	4 4	4 5	7 5	6 5	4 8	4 4	3 9	**51 8**
Heat production												
11 0	11 0	11 4	11 9	10 4	11 6	11 7	7 0	7 5	8 1	8 4	8 3	**118 3**
Others												
1 7	1 5	1 5	2 3	2 4	2,4	2,6	2 4	3 7	3,2	3,7	4	**31 4**

Distribution of water consumption at the plant is determined by calculation according to the specific consumption rates set at the plant

- sausage making production — 6 1 m^3/t
- raw materials workshop — 3 66 m^3/t

- fart making production and meat and bone meal — 9 8 m^3/t
- artificial cold production — 3 5 $m^3/Gcal$
- thermal energy production — 2 2 $m^3/Gcal$

No detailed balance of the water consumption has been done at the plant

Drinking water consumption

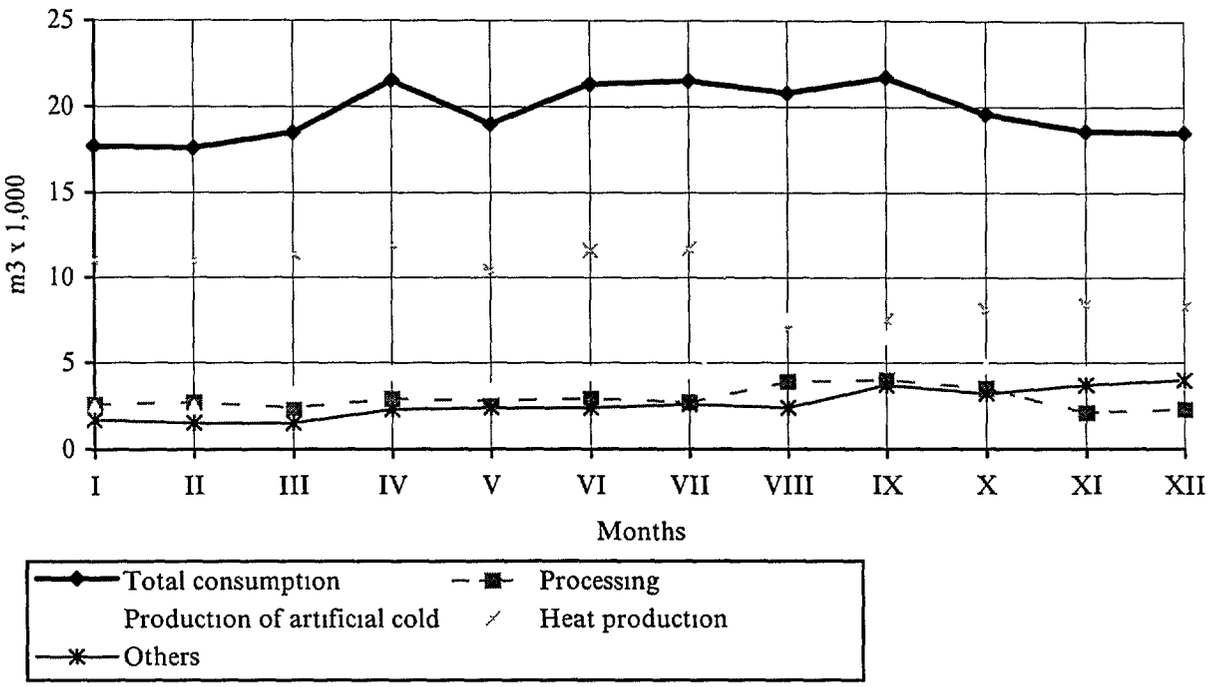


Fig 16

In summer the amount of the consumed water rises by 25 to 30 per cent, which is accounted for by rising in the production level of the artificial cold Due to absence of water metering, it does not seem possible to explain the behavior of the water consumption at the plant boiler-house during a year Costs of the water used for production of heat equal to 50 per cent of the total consumption shall be considered overestimated by 30 to 40 per cent, as they do not correspond to the amount of the produced steam, condensate losses and to the costs of the consumption by the boiler-house itself It is reasonable to arrange metering the water consumption at the inlet to the boiler-house

Distribution of water consumption between the basic structural units of the plant

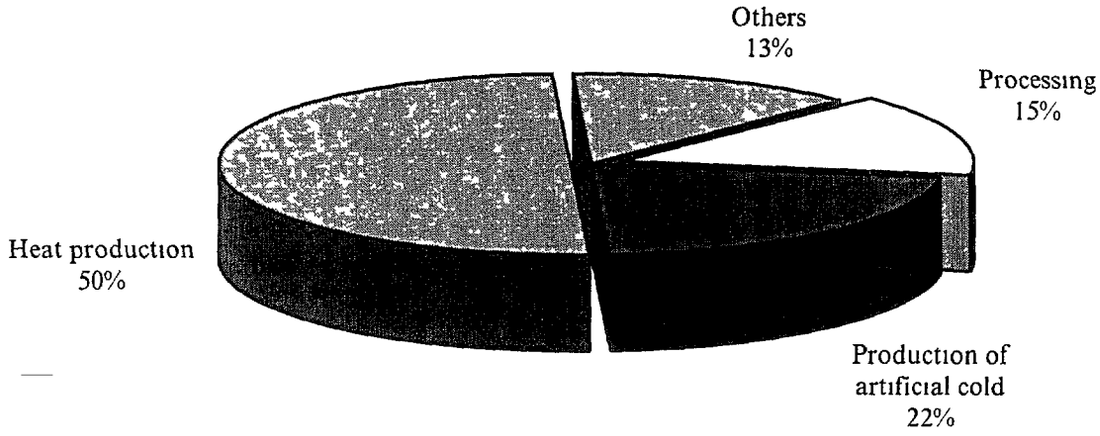


Fig 17

The basic reserves in water saving are

- increase of the portion of the returned condensate from 35 per cent to the calculated value of 43 per cent,
- improvement of the efficiency of the water circulation supply system in the cooling- and-compressor workshop,
- decrease of water consumption for the sanitary washing of the walls, floors, equipment

6 O SPECIFIC ENERGY CONSUMPTION

When implementing energy saving projects a very important measure is determining the basic indicators of the specific energy resources consumption As there is no metering systems at the plant itself and the assortment of the produced products is very wide, it does not seem possible to receive objective information in regard of the actual energy consumption used for production of 1 tonne of products and compare it with the better figures for the industry

In this section we tried to estimate approximately the energy efficiency of the basic production and of the currently used system of settlements for the energy resources used within the territory of the plant

6 1 Specific energy consumption per 1 tonne of the main kinds of products for 1997

Table 9

Months	Production level	Electric power for the production needs		Thermal energy		Artificial cold	
		kW h	kW h/t	Gcal	Gcal/t	Gcal	Gcal/t
January	304	357,500	1,235	2,410	7 93	510	1 68
February	310	353,900	1,142	2,295	7 40	473	1 53
March	340	302,700	890	2,325	6 84	513	1 51
April	363	341,700	941	2,071	5 70	542	1,49
May	377	307,300	815	1,518	4 02	564	1 50
June	336	610,300	1,816	1,252	3 73	743	2 21
July	399	531,000	1,331	1,421	3 56	1,010	2 53
August	370	617,700	1,669	1,163	3 14	921	2 49
September	423	638,800	1,510	1,634	3 86	789	1 87
October	375	402,700	1,074	1,875	5 00	650	1 73
November	303	376,100	1,241	1,819	6 00	523	1 73
December	367	432,400	1,178	2,193	5 98	481	1 31
	4,267	**5,272,100**	**1,236**	**21,976**	**5 15**	**7,719**	**1 81**

Specific electric energy consumption

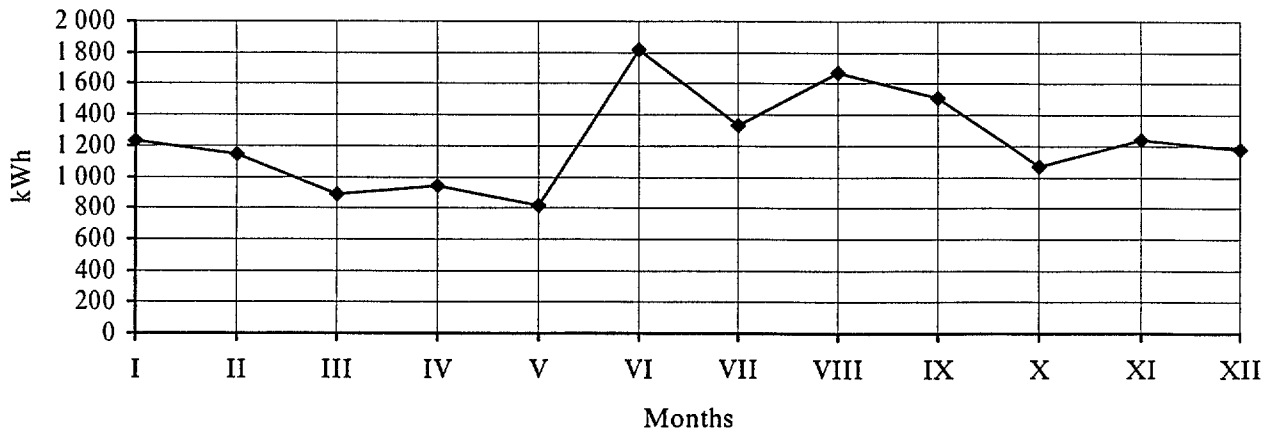


Fig 18

Specific thermal energy consumption

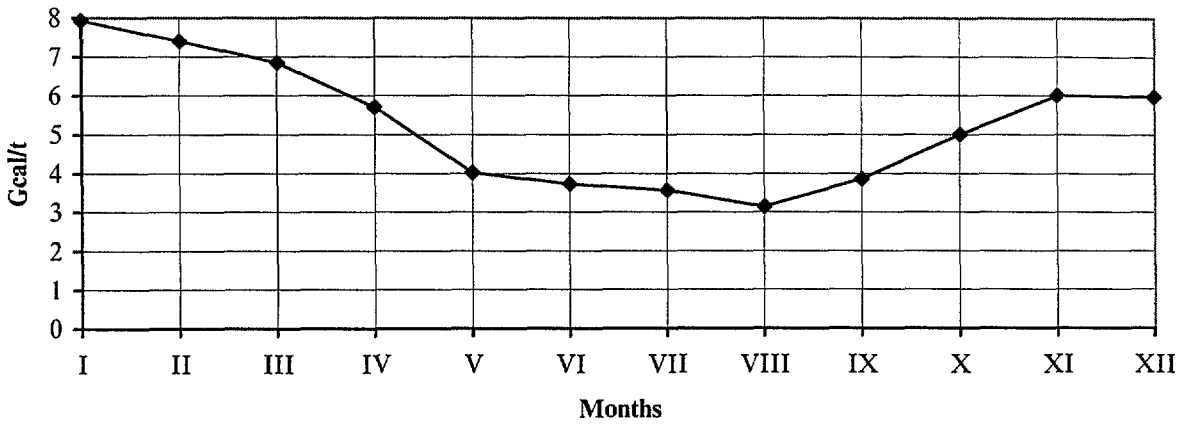


Fig 19

Specific consumption of cold

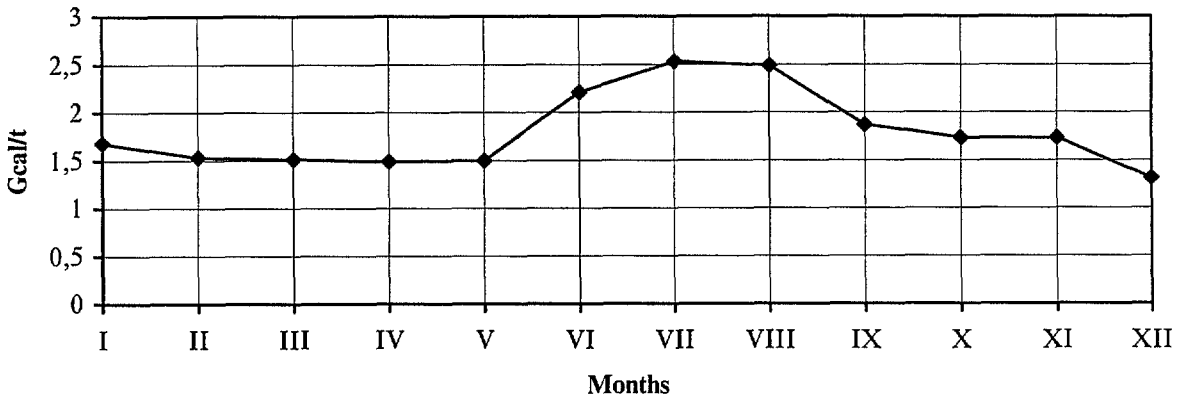


Fig 20

In 1997 providing the average productivity level for the basic sort of products 355 tonnes per month (16 tonnes per day) the specific energy consumption was as follows

- electric power — 1 236 kW h/t (890 to 1,670 kW h/t)
- thermal energy — 5 15 Gcal/t (3 6 to 7 9 Gcal /t)
- artificial cold — 1 8 Gcal/t (1 3 to 2 5 Gcal /t)
- water — 55 3 m^3/t (50 4 to 61 m^3/t)

The specific consumption of electric power and of the artificial cold increase in winter time by 1 5 to 2 times as the need for cold rises Specific consumption of thermal energy rises in winter time by 1 8 to 2 0 times as the heating load increases

The data received for the total specific consumption are approximate To get more precise estimations for the energy efficiency consumption in Table 10 specific consumptions of energy per 1 tonne of products for the basic production subdivisions are given

Table 10

Months	Production level, tonne	Electric power used on production of cold		Electric power used in the sausage making and raw materials workshops		Thermal energy for the sausage making and raw materials workshops	
		kW h	kW h/t	kW h	kW h/t	Gcal/t	Gcal/t
I	304	159,500	524 7	80,600	265 1	860	2 83
II	310	205,900	664 2	65,100	210 0	785	2 53
III	340	203,700	599 1	30,700	90 3	850	2 50
IV	363	182,700	503 3	71,800	197 8	912	2 51
V	377	204,300	541 9	23,500	62 3	972	2 58
VI	336	361,300	1075 3	128,600	382 7	850	2 53
VII	399	440,000	1102 8	26,700	66 9	1,118	2 80
VIII	370	456,700	1234 3	55,100	148 9	702	1 90
IX	423	371,800	879 0	134,600	318 2	1,006	2 38
X	375	242,700	647 2	76,000	202 7	895	2 39
XI	303	212,100	700 0	63,200	208 6	637	2 1
XII	367	225,400	614 2	78,800	214 7	929	2 53
Total	**4,267**	**3,266,100**	**765 4**	**834,700**	**195 6**	**10,516**	**2 46**

Specificelectric power consumption for production of cold to be used for the processing needs at the plant

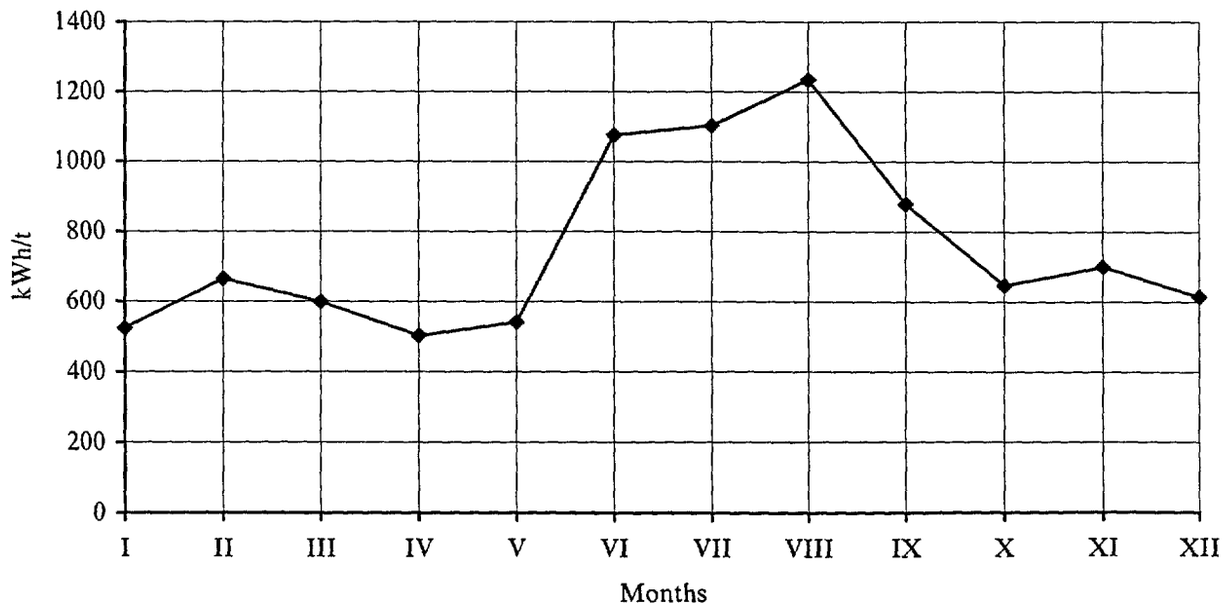


Fig 21

Specific electric power consumption
by the sausage making and raw materials workshop

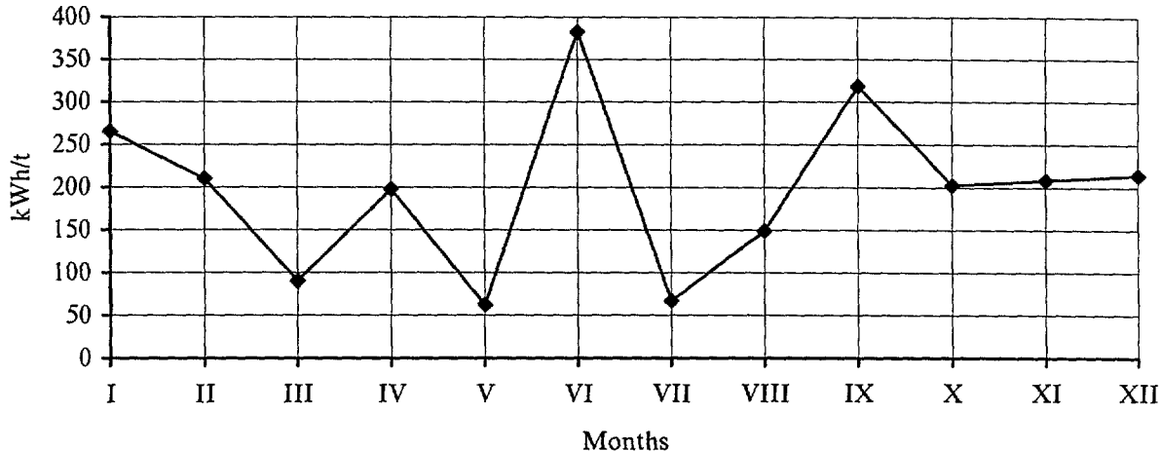


Fig 22

The specific electric power consumption for the processing needs is 196 kW h per 1 tonne of the meat products and vary between 62 and 382 kW h As the sausage making and raw materials workshops consumption of electric power is 19 per cent, it is reasonable to mount additional meters at the basic processing areas aiming at providing control of the specific consumption of energy resources at the plant

Specific thermal energy consumption rate
for the sausage making and raw materials workshops

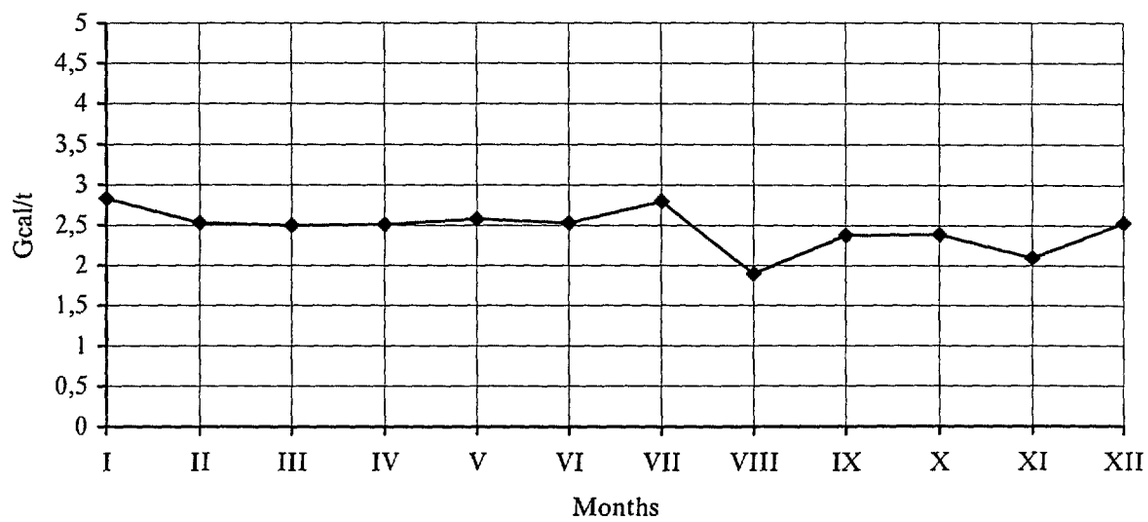


Fig 23

The specific thermal energy consumption per 1 tonne of sausage products is in average 2 46 Gcal/tonne, and it varies between 1 9 to 2 8 Gcal/tonne There should be drawn attention to the increased levels of the specific energy consumption as compared that with the calculated values given in the steam and condensate balance for the plant, which suggests the idea of a possible energy saving, first of all, in the thermal chambers

As the thermal energy consumption by the sausage making and raw materials workshops is about 49 per cent of the total thermal energy consumption at the plant, a detailed audit of the thermal and smoking chambers should be carried out, and introduction of metering the consumption of the steam coming to the sausage making and raw materials workshops is required

Analysis of operation of the refrigerating system for 1997

Table 11

Months	**Electric power consumption for production of cold**	**Cold production**		**Electric power consumption for production of 1 Gcal of cold**	**Coefficient of performance of the refrigerating system**
	kWh x 10³	*Gcal*	*kWh x 10³*	*kWh/Gcal*	
I	334	1,068	1,242	313	3 72
II	454	1,043	1,213	435	2 67
III	507	1,277	1,485	397	2 93
IV	471	1,397	1,625	337	3 45
V	607	1,676	1,949	362	3 21
VI	863	2,038	2,370	423	2 75
VII	991	2,275	2,646	436	2 67
VIII	1012	2,041	2,374	496	2 35
IX	850	1,804	2,098	471	2 47
X	588	1,575	1,832	373	3 12
XI	541	1,334	1,551	406	2 87
XII	531	1,133	1,318	469	2 48
Total	**7,749**	**18,661**	**21,703**	**415**	**2 80**

Electric power consumption for production of 1 Gcal of cold

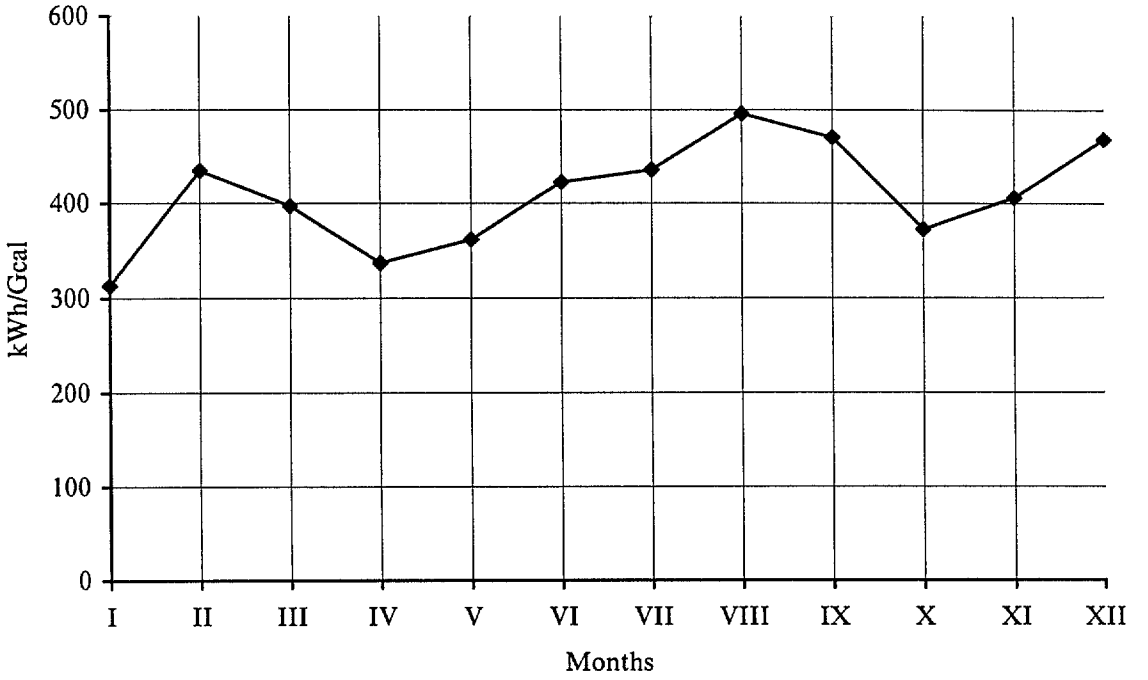


Fig 24

The average electric power consumption for production of 1 Gcal of cold was 415 kW h and it has not any certain dependence on the season of the year The refrigerating coefficient of the system equal to the ratio of the amount of the artificial cold to the total amount of the electric power consumed for its production and determining the operation efficiency of the refrigerating system is in average equal to 2 8 and it varies during a year from 2 35 to 3 72

The given data proving a high efficiency of the refrigerating system do not correspond to the real state of things, as they are based on subjective figures for the consumed power and the amount of the produced cold The currently existing system of settlements is not sensitive to the energy saving measures

To determine the actual value of the refrigerating coefficient and to estimate the energy saving measures additional meters of electric power consumption by the refrigerating machines should be mounted and a detailed energy balance for the refrigerating system should be done aiming at precising the real load of the plant in regard of cold

6 2 Analysis of the plant operation during March 2 - 16 1998

Analysis of the plant operation during March 2 - 16, 1998 allows to estimate the permanent constituent to the thermal energy costs that does not depend on the production level of the basic products, and to precise the value of the specific energy resources consumption for production of 1 tonne of sausage products

The results are given in Table 12 and in Fig 25 - 31

Table 12

Date	Production level	Thermal energy consumption for the basic processes	Electric power consumption by		Total
			sausage making workshop	raw materials workshop	
	tonne	*Gcal*	*kWh*	*kWh*	*kWh*
2 03	13 9	68	2,542	586	3,128
3 03	12 9	61	2,245	584	2,829
4 03	14 4	68	1,872	588	2,460
5 03	12 8	58	2,224	572	2,796
6 03	13 2	54	1,937	588	2,525
7 03	9 3	57	2,194	568	2,762
8 03	0	44	24	560	584
9 03	12 3	61	2,376	448	2,824
10 03	11 9	60	2,481	572	3,053
11 03	13 1	62	2,634	580	3,214
12 03	13 9	60	2,488	596	3,084
13 03	12 4	51	2,671	356	3,027
14 03	0	37	24	312	336
15 03	10 1	59	2,589	248	2,837
16 03	14 6	63	2,273	400	2,673
Total	**164 8**	**863**	**30,574**	**8,578**	**38,222**

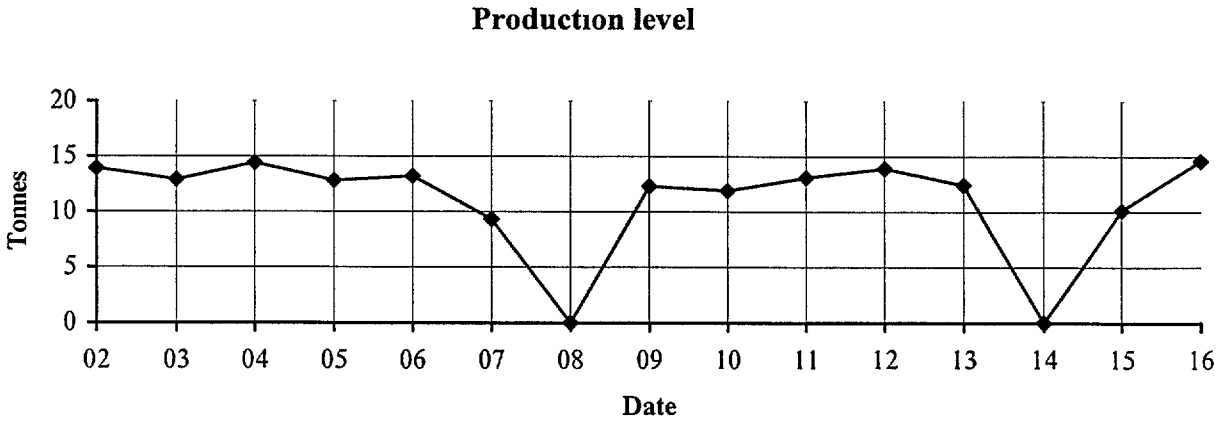


Fig 25

Thermal energy consumption for the basic production

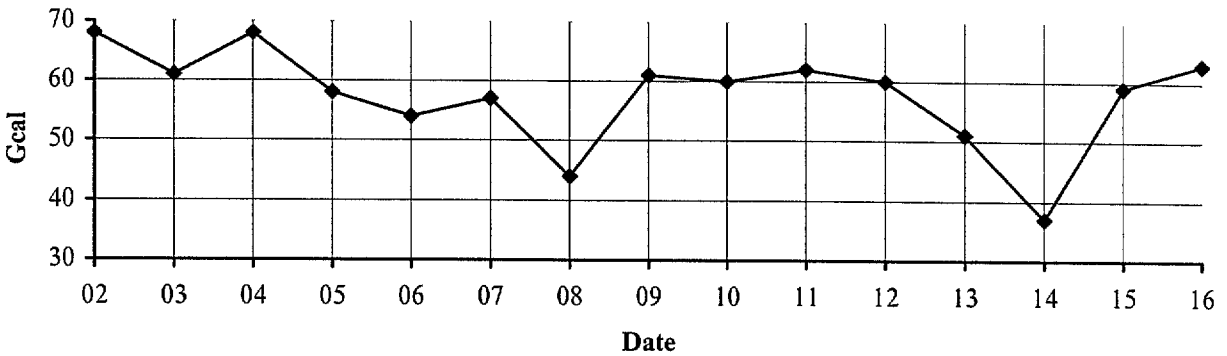


Fig 26

Electric power consumption
by the sausage making and raw materials workshops

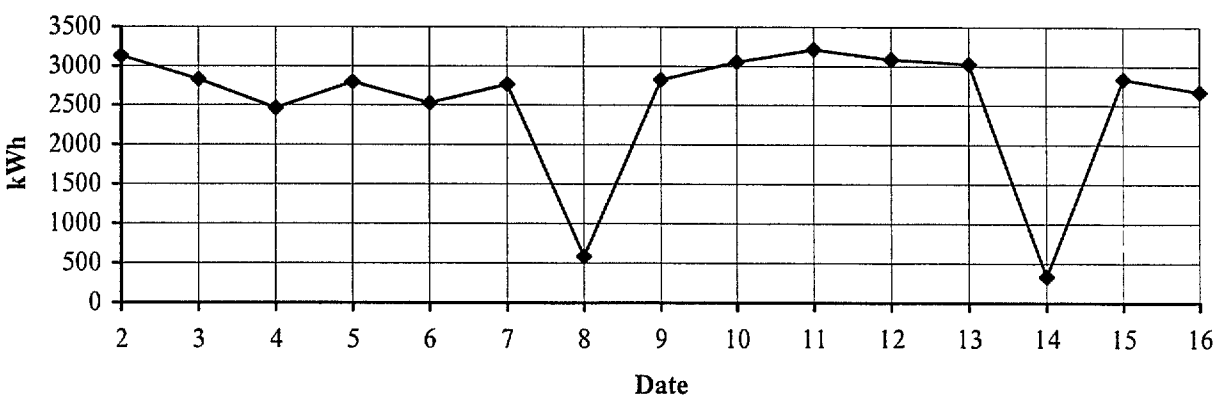


Fig 27

Thermal energy consumption for the basic production versus the production level

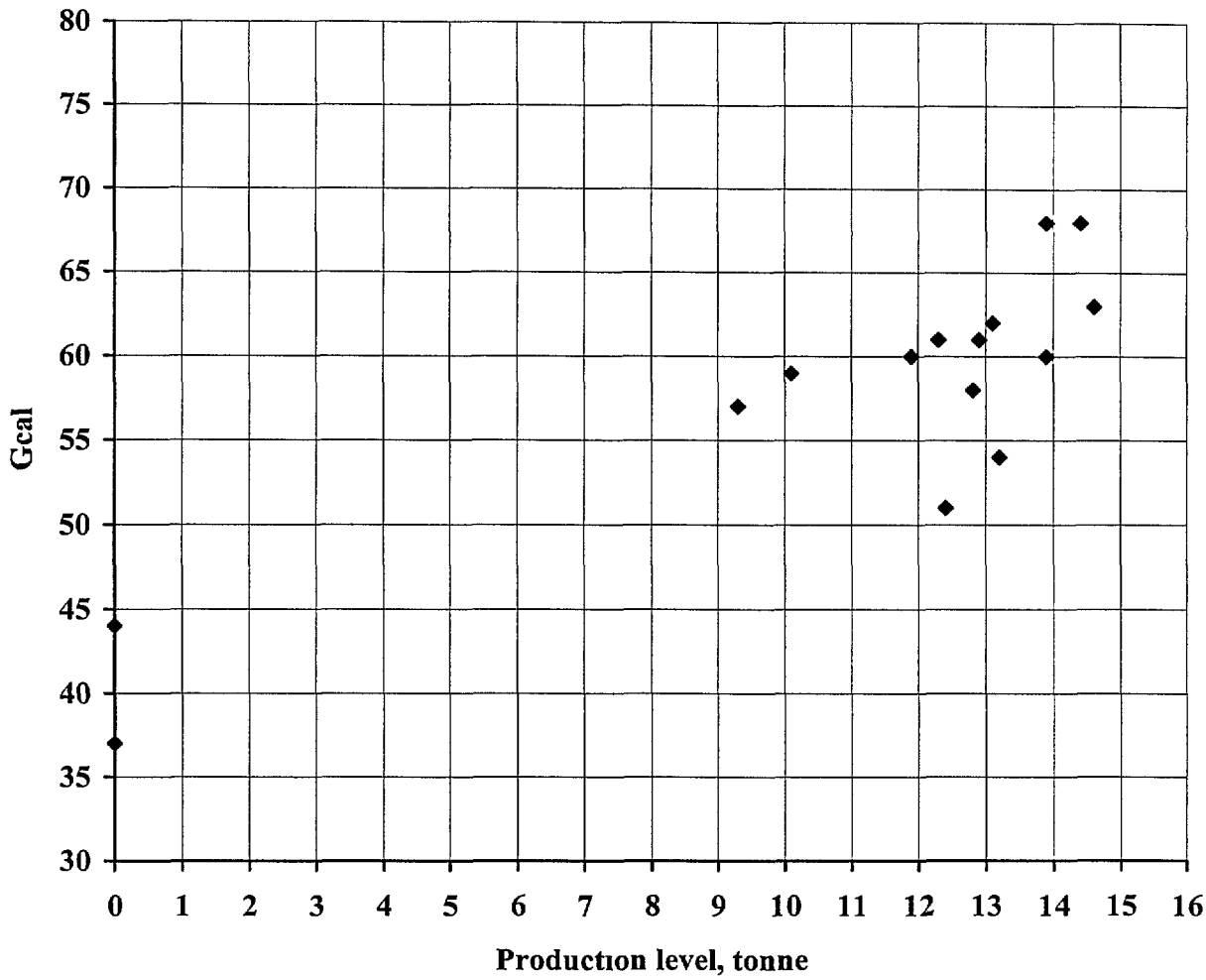


Fig 28

The average consumption of thermal energy at production level of 14 to 15 tonnes per day was 63 Gcal As it can be seen from the figure, on day-offs (March 8 and March 14) the consumption of thermal energy independent on the production level was about 41 Gcal per day , or 65 per cent of the total heat consumption Taking into consideration large importance of the permanent constituent, it is reasonable for the enterprise to analyze in more details operation of the heat using equipment on day-offs with the aim to find energy saving opportunities

On some days, providing the same production level, there was observed a significant variation in thermal energy consumption Reasons for this are unknown Most probable, the cause is incorrect relative information

Specific thermal energy consumption for the basic production versus the production level

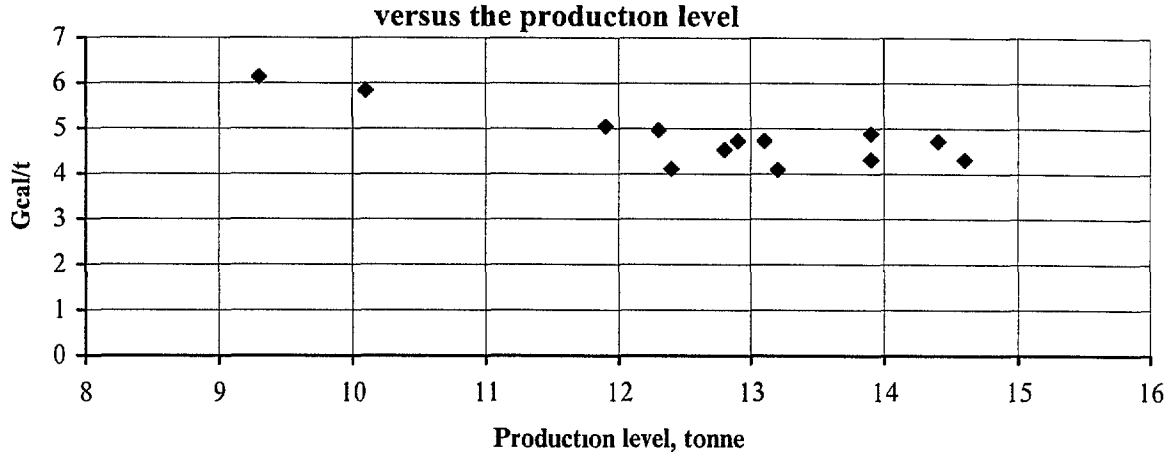


Fig 29

The efficiency of heat utilization increases versus the production level and at the production capacity of 14 to 15 tonnes per day it is of about 4 to 4 5 Gcal per 1 tonne of products This figure is 1 5 times more than the calculated value, which testifies to good possibilities for the energy saving at the plant

Electric power consumption by the sausage making and raw materials workshops versus the production value

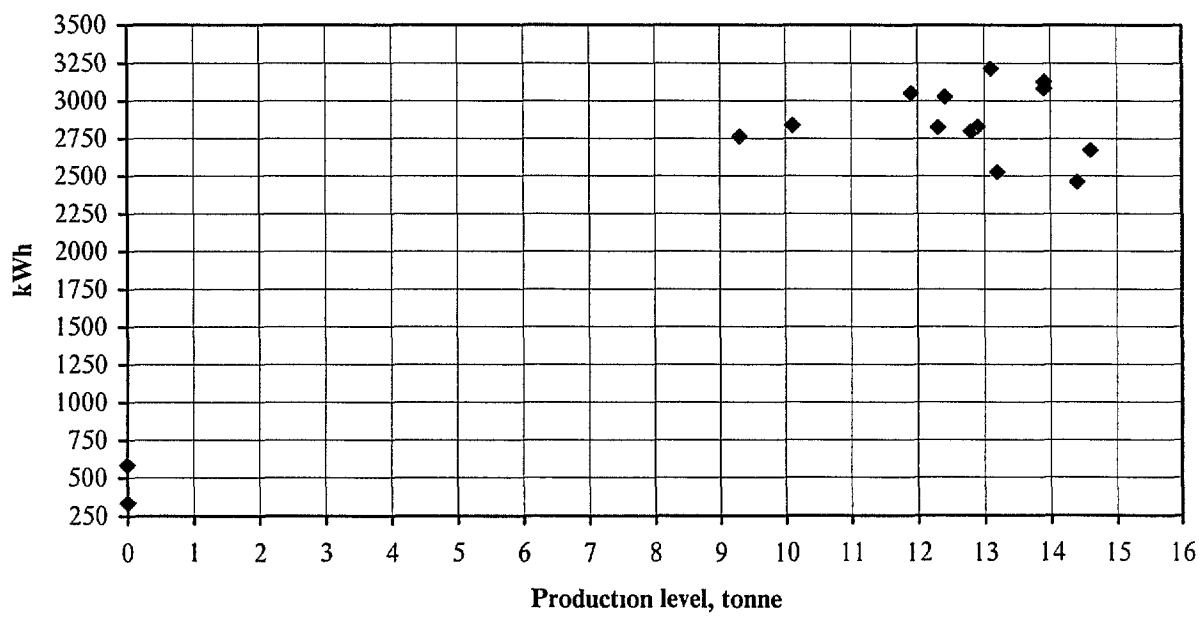


Fig 30

Specific electric power consumptiuin by the sausage making and raw materials workshops versus the production level

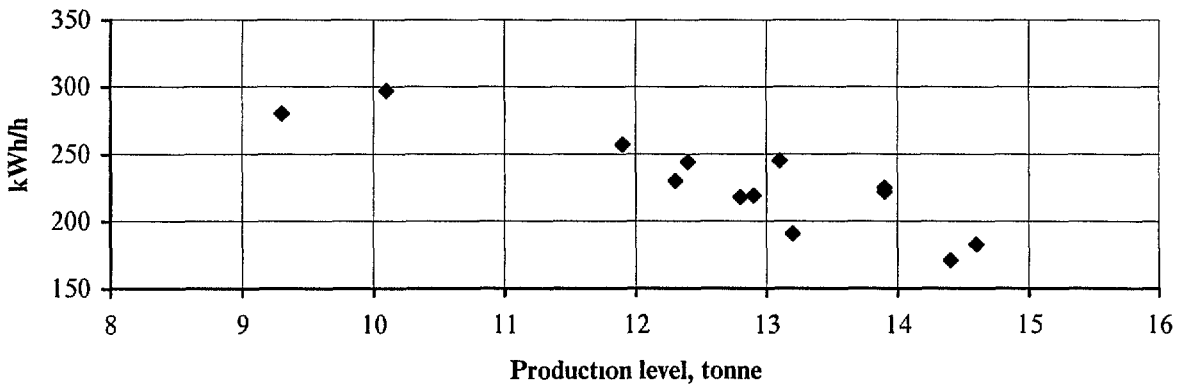


Fig 31

The efficiency of the electric power consumption rises versus the production level and at the production level of 14 to 15 tonnes per day it is of about 175 kW h per 1 tonne of products There are noticeable variations in the electric power consumption at the constant production level This suggests the idea of the imperfectness of the current system of metering the electric power consumption and that of the production level, its insensitiveness to the energy saving measures

7 0 PREVIOUS ENERGY IMPROVEMENTS

Each year energy saving measures are worked out at the plant The below measures were implemented in 1997

1 An automatic system for metering consumption of natural gas at the boiler-house was installed
2 Return and metering of the condensate from the aside user was arranged
3 Cold external air for cooling meat products in the winter period was used
4 The costs of the electric power consumption for cooling meat products were decreased by disconnection of one of them
5 The current repair of the insulation of the steam pipe lines and of the hot water supply ducts

In 1998 there is planned as follows

1 To modernize the cooling tower in the cycled water supply system in the compressor-and-refrigerating workshop
2 Introduction of an automatic system for regulating natural gas in *DKVR-6,5/13* steam boilers

According to the planned measures estimates concerning the expected energy consumption saving and the payback period were made

8 0 ENERGY CONSERVATION MEASURES

Implementation of energy management program (ECO - 1)

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

At *Kyiv Meat Processing Plant*, as with most industries in Ukraine, in the past the energy costs were significantly subsidized and plentiful, therefore and the energy saving was not a major consideration in the plant operations

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

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

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

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

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

<u>It is proposed</u> to provide the enterprise with the needed measuring instruments to identify and quantitatively assess energy conservation opportunities, independently determine the priority of the costs on energy savings, decrease the energy consumption and control energy conservation
Expected saving (based on experience of other factories)

- electric power — 488,000 kW h
- natural gas — 360,000 m^3

- drinking water — 12,000 m^3

The project cost — USD 48,980
Payback period— 1 year

Automatic systems for metering energy consumption (ECO -2)

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

The system for metering the energy consumption at the plant based on calculated rates is insensitive to the energy saving measures Objective estimation of the expected energy saving seems to be quite a problematic task, the same is valid in relation of having a guarantee for the spent costs to be paid back after implementation of the energy conservation measures

It is proposed to up-grade the available system for metering energy consumption And as one of the variants for the modernization a set of technical facilities ITEK is proposed that is a set of measuring instruments with the corresponding characteristics and is designed for a continuous or regular checking/recording physical values

Expected saving

- electric power — 293,000 kW h
- natural gas — 216,000 m^3

The project cost — USD 49,500
Payback period— 1 7 years

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

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

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

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

Expected saving

- natural gas — 108,000 m^3

The project cost — USD 7,000
Payback period— 0 75 years

Automatic control of the burning process and of the low pressure in the furnace of DKVR-10/13 boiler (ECO - 4)

1 The pressure in the boiler equal to 7 0 to 7 5 barg is supported automatically by changing the flow rate of gas to the burners But the air pressure at this time for the burning process remains the same While performing the audit on March 17 - 18 the experts were checking the operation of Boiler #3 using "BACHARACH"gas analyzer, the boiler was operated in the mode of the automatic pressure control The oxygen content in the exhaust gases was varying from 13 2% to 9 2%, the heat losses with the exhaust gases varied from 13 2 to 9 4%, that is the efficiency was changed by 3 8% The similar behavior was registered for Boiler #4 The main reason for the inefficient combustion mode is absence at the boilers of an automatic system for controlling the "fuel-to-air" ratio

2 *DKVR-10/13* Steam boiler (#4) is equipped with *D-13,5* exhaust fan with a 55-kW electric motor and *VD-10* fan with a 22-kW electric motor The power margin of the exhaust fan is 250%, the power margin of the fan is 150% That was proved by the measurements made by means of the power factor meter *TIF 2300* The power factor (cos φ) varied in the range of from 0 35 to 0 45 A large margin in the power factor results not only in the electric power overconsumption, but it does not allow to support the "fuel-to-air" ratio and the low pressure in the furnace if the thermal load of the boiler changed

It is proposed to mount at Boiler *DKVR-10/13* #4 an automatic system for controlling the "fuel-to-air" ratio and the low pressure in the furnace If the gas consumption in the boiler changes, the air consumption is changed automatically following the change of the speed rotation of the fan with a correction due to the oxygen content in the exhaust gases At the same time there is automatically supported a constant low pressure in the furnace by changing the speed rotation of the exhaust fan

Expected saving

- electric power — 46,000 kW h
- natural gas — 202,000 m^3

The project cost — USD 21,700
Payback period— 1 13 years

Redesigning of *DKVR-6,5/13* Steam Boiler for water heating operation mode (ECO - 5)

The plant has a water heating system that operated according to the temperature schedule of 95 to 70^{0}C The heating load of the plant is about 53,000 Gcal per year, which is equivalent to consumption of about 780,000 m^3 of natural gas There are 4 steam boilers installed in the boiler-house Heating of the delivery water is done in steam and water case-tube heaters not equipped with steam traps The current heat supply system is less efficient as compared it with the one where delivery water is heated in water heating boilers The Ukrainian operation experience has proved a high effectiveness of transferring *DKVR*-type steam boilers on the water heating operation mode, which allows to decrease the fuel consumption for the heating system by 25 to 30 per cent, as well as decrease the costs of repair works for the case-tube heaters, decrease electric power consumption by the delivery water pumps and to improve functioning of the heat supply system

It is proposed to redesign one of the three available *DKVR - 6,5/13* steam boilers for operating them in the water heating operation mode The boiler redesigning includes mounting partitions in the boiler drum, changing the water circulation in the economizer and in the furnace screens, changing

the automatic control and protection system The thermal production capacity of the redesigned boiler will be 4 5 GCal/hour, which will provide the thermal load of the heat supply system

Expected saving

- electric power — 16,000 kW h
- natural gas — 195,000 m^3

The project cost — USD 16,500
Payback period— 0 94 years

Steam traps (ECO - 6)

According to the plant energy balance, the hot water supply system uses 2,880 Gcal of heat per year The steam and water heaters have no steam traps, which significantly worsens the efficiency of operation of the heaters, results in heat losses with he steam flash Besides, there are no steam traps after the following steam using items of the processing equipment

- calorifer of the inlet fans in the ancillary rooms block (1 unit),
- calorifer of the conditioner in the species drying room (1 unit),
- drying machines in the laundry room (5 units),
- cloths dryers (2 units)

The heat consumption by the said equipment, according to the balance, is 189 Gcal per year

Survey of the steam and condensate system and measurements of the temperature by means of *"Mikron"* infra-red thermometer showed that many steam traps in the thermal chambers do not operate properly, or they are absent at all Out of 24 steam traps 10 do not operate, 3 are absent The approximate thermal energy consumption by the sausage making workshop is about 8,000 Gcal per year

It is proposed to mount the lacking and to replace the faulty steam traps, which will increase the efficiency of steam using by the said items of the equipment by more than 15 per cent

Expected saving

- natural gas — 120,000 m^3

The project cost — USD 15,860
Payback period— 1 5 years

Steam and water mixing stations (ECO - 7)

A peculiar feature about the meat processing plant is the necessity to wash every day the equipment, floors and walls in the rooms with hot water with the temperature of about 55 to 60^{0}C The heat consumption for the hot water supply system is about 2,800 Gcal per year, from that, in accordance with the thermal energy balance for the plant about 50 per cent or 1,400 Gcal is used for washing The water consumption for that is about 28,000 m^3 per year Water is heated in the steam and water heater and supplied by pumps to the washing points The washing water hoses have no special stopping valves, which results in significant waste of water while the worker is moving from one working place to another

It is proposed to start operating steam and water mixing stations allowing to heat water by directly mixing steam and water and automatically support a set temperature The station equipment includes a "cap-pistol" that automatically stops water supply

Expected saving

- natural gas — 62,000 m^3

The project cost — USD 16,640
Payback period— 1 14 years

Control of the temperature schedule in the refrigerating and freezing chambers (ECO - 8)

The efficiency of operation of the refrigerating system depends a lot on the operation level of the freezing and refrigerating chambers

The measurements performed in the process of the audit showed a significant variation of temperature in different points in the chamber Inside the chambers incandescent lamps are constantly lit The ceiling and floor registers of the evaporators are irregularly covered with ice if different thickness There are no plastic thermoinsulating curtains on the gates During the operations there are "leaks" of the cold air and warm air, that occurs through the open gates

No regular temperature registering is done in the refrigerating and freezing chambers, which does not allow to control and analyze their modes and undertake in due time measures aimed at supporting the maximum efficiency of their operation

It is proposed to equip each refrigerating chamber with a digital temperature recorder Availability of a temperature control will enable the following

- to assess the real situation in each chamber and to choose the most effective ones,
- to identify in due time degradation in their operation efficiency, analyze the reasons for that and undertake measures,
- to make more regular defrostration of the evaporators,
- to improve the operation level of the chambers and to optimize loading of the chambers,
- to estimate the implemented energy conservation opportunities and reach decreasing in the specific consumptions per unit of the products

Expected saving

- electric power — 212,000 kW h

The project cost — USD 6,830
Payback period— 0 9 year

9 0 EFFECT OF IMPLEMENTING THE RECOMMENDATIONS ON THE ENVIRONMENT

Saving of energy resources that is possible in the result of implementation of the developed energy saving opportunities (ECOs) is directly connected with decreasing the harmful emissions into the environment

Initial data for calculations

The average amounts of the harmful emissions per 1,000 kW h of the produced electric power within the facilities of the Ministry for Energy of Ukraine were as follows

CO - carbon monoxide - 0 51 kg
NO_x - oxides of nitrogen - 2 177 kg
SO_2 -sulfur dioxide - 9 89 kg
Ash - 4 365 kg

To estimate the emissions into the atmosphere gained by saving heat with the consumer there were set the following specific amounts of emissions per 1,000 m^3 of natural gas when burning natural gas the DKVR-type steam boilers operated at the plant

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

Calculation of the decrease of amount of the emissions into the atmosphere

- Expected yearly saving providing implementation of the ECOs
  - natural gas - 1,263,000 m^3
  - electric power - 1,055,000 kW h
- Decrease of harmful emissions into the atmosphere

CO - 1,263,000 m^3 0 28 kg/10^3 m^3 + 1,055,000 kW h 0 5 kg/10^3 kW h = 881 kg
NO_x -1,263,000 m^3 1,215 kg/10^3 m^3 + 1,055,000 kW h 2 2 kg/10^3 kW h = 3,856 kg
SO_2 - 1,055,000 kW h 9 9 kg/10^3 kW h = 10,445 kg
Ash - 1,055,000 kW h 4 4 kg/10^3 kW h = 4,642 kg

The total decrease of harmful emissions - 19 8 tonnes per year

APPENDIX A ENERGY CONSERVATION OPPORTUNITIES (ECOs)

Energy Conservation Opportunities

ECO - 1	Introduction of energy management program
ECO - 2	Modernization of the system for energy consumption metering
ECO - 3	Optimization of gas burning in steam boilers
ECO - 4	Automatic control of combustion and of the low pressure in the furnace of *DKVR-10/13* boiler
ECO - 5	Redesigning of *DKVR-6 5/13* boiler for water heating operation mode
ECO - 6	Steam traps
ECO - 7	Steam and water mixing stations
ECO - 8	Control of the temperature schedule in refrigerating and freezing chambers

Energy Conservation Opportunities

ECO - 1 Introduction of an energy management program

Description of the opportunity

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

While performing the audit there were found a lot of costless and low-cost energy saving opportunities that can become of a significant benefit

For example, estimation of the efficiency of operating refrigerating machines (25 units), thermal chambers (24 units), refrigerating and freezing chambers, other similar equipment will allow the operation of the most efficient equipment and to withdraw out of operation the inefficient ones

Providing availability at the enterprise of a measuring system for a quantitative and qualitative assessment of energy saving opportunities, introduction of an energy management system is a possibility

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

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

- a contactless thermometer
- an ultrasonic leak detector (ammonia, natural gas, compressed air)
- a wire thermoanemometer
- a three-phase energy analyzer
- a tachometer
- a digital contact thermometer
- an illumination meter
- an ultrasonic contactless flow rate meter
- a power meter
- a power factor meter (cos φ)
- a portable temperature/humidity/'dew point" recorder
- a computer with a printer

Providing availability at the enterprise of a set of the measuring instruments, it is also proposed to introduce at the plant a position of the energy manager It is reasonable for the energy manager to undergo a special training course in the Energy Managers Training Center Center (Kyiv City, *National Technical University of Ukraine "Kyiv Politechnical Institute"*) The basic task of the energy manger is monitoring of energy using systems, development of real rates with the aim

of continuous monitoring for their observation by the energy users and decreasing the total energy consumption at the plant

The issues to be in charge of the energy manager working with the plant personnel should include the following aspects

- training the plant personnel to the energy management practice,
- stimulation of the plant personnel in finding energy conservation opportunities at their production areas and in their workshops,
- awarding the plant personnel for finding out potential energy conservation opportunities,
- quantitative estimation of the economic effect for each of the energy conservation opportunities and of the payback period for the corresponding investments,
- planning and correction of a 5-year strategy plan of the energy management development aimed at implementation of energy conservation opportunities,
- implementation of energy conservation opportunities if they are financed or costless,
- following-up of the energy conservation opportunities after their implementation and a quantitative assessment of the actual saving of the costs,
- dissemination of the successful experience of implemented energy conservation projects as well as their lessons,
- repetition of successful energy conservation projects at all production areas and in all workshops at the given plant

Calculation of a yearly energy saving

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

The energy saving will be as follows

1 Electric power 9,755 000 kW h • 0 05 = 488,000 kW h
2 Natural gas 7,200,000 m^3 • 0 05 = 360,000 m^3
3 Water 236,000m^3 • 0 05 = 12,000 m^3

Calculation of a yearly saving of costs

1 If 1,000 kW h cos USD 37, the saving of the electric power cost will be
488,000 kW h • USD 37 = USD 18,056
2 If 1,000 m^3 of gas cost USD 86 7, the saving of gas costs will be
360,000 m^3 • USD 86 7 = USD 31,212
3 If 1,000 m^3 of water cost USD 57 5, the saving of water costs will be
12,000 m^3 • USD 57 5 = USD 690

The total saving of the energy costs will be
USD 18,056 + USD 31,212 + USD 690 = USD 49,958

Commissioning costs

Approximate cost of a set of the measuring instruments is USD 24,000
The costs of implementation of an energy management system, as it is shown by practice, are about 50 per cent of the expected saving, or USD 49,958 • 0,5 = USD 24,979

The total costs are USD 24,000 + USD 24,979 = USD 48,979

<u>The simple payback period is</u> USD 48,979 USD 49,958 ≈ 1 year = 12 months

ECO - 2 Modernization of the system for energy consumption metering

Description of the opportunity

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

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

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

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

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

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

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

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

ITEK-220, ITEK-320 are designed to be used in automatic systems for commercial and telemetric monitoring of the provided and consumed liquids, steam and thermal energy together with any standard primary transducers for measurements of flow rate, temperature and pressure differences that have rated output parameters, at the suppliers' (Heat Power Plants, heat and power supply lines, boiler-houses) and at the consumers' (industrial plants, utility objects) The design of ITEK-X20

meets the requirements of *RD-50-213-80, RP34-70-010-85, GOST 6651-84* and *R75 MOZM* ITEK-220, ITEK-320 are designed to be used a the objects belonging to Metering Group 1 (up to 4 objects) of a complicated network of the incoming and outcoming pie lines (ITEK-220) and to Metering Group 1 and 2 (1 objects) (ITEK-320)

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

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

Calculation of a yearly energy saving

Electric power consumption for 1997 was about 9,755,000 kW h, that of natural gas was 7,200,000 m^3

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

1) electric power saving 9,755,000 kW h • 0 03 = 293,000 kW
2) natural gas saving 7,200,000 m^3 • 0 03 = 216,000 m^3

Calculation of yearly costs

1 If 1 000 kW h cost USD 37, the saving of electric power costs will be
293,000 kW h • USD 37 = USD 10,841
2 If 1 000 m^3 cost USD86 7, the saving on gas costs will be
216,000 m^3 • USD 86 7 = USD 18,727
The total energy saving will be
USD 10,841 + USD 18,727 = USD 29,568

Operation costs

The approximate cost of an automatical metering system in the expected scope will be USD 49,500

The simple payback period is USD 49,500 USD 29,568 = 1 7 yr ≅ 20 months

ECO - 3 **Optimization of burning gas in the steam boilers**

Description of the opportunity

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

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

"Scheduling" the operation modes for the steam boilers *DKVR-6 5/13* #3 and *DKVR-10/13* #4 by means of a portable combustion analyzer "BACHARACH" showed a real opportunity to save gas by 1 5 to 2 0 per cent

For example, by changing the air supply there was provided decreasing of the heat losses with the output gases in Steam Boiler #4 from 11 3 to 10 4 per cent, or by 0 9 per cent, that at Steam Boiler #4 - from 13 3 to 9 2 per cent, or by 4 1 per cent

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

Calculation of a yearly saving of natural gas consumption

1 Improvement of the efficiency of the equipment (set) — 1 5%
2 Yearly gas consumption at the plant (in 1997) — 7,196,000 m^3
3 Expected yearly gas saving
   7,196,000 m^3 • 0 015 = 107,900 m^3

Calculation of a yearly saving of costs

1 1,000 m^3 of gas cost USD 86 7
2 Yearly saving
   107,900 m^3 • USD 86 7 = USD 9,355

Commissioning costs

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

The simple payback period is USD 7,000 USD 9,355 = 0 75 yr ≅ 9 months

ECO - 4 Automatic control of the burning process and of the low pressure in the furnace of *DKVR-10/13* boiler

Description of the opportunity

1 The pressure in the boiler equal to 7 0 to 7 5 barg is supported automatically by changing the flow rate of gas to the burners But the air pressure at this time for the burning process remains the same While performing the audit on March 17 - 18 the experts were checking the operation of Boiler #3 using "BACHARACH"gas analyzer, the boiler was operated in the mode of the automatic pressure control The oxygen content in the exhaust gases was varying from 13 2% to 9 2%, the heat losses with the exhaust gases varied from 13 2 to 9 4%, that is the efficiency was changed by 3 8% The similar behavior was registered for Boiler #4 The main reason for the inefficient combustion mode is absence at the boilers of an automatic system for controlling the "fuel-to-air" ratio

2 *DKVR-10/13* Steam boiler (#4) is equipped with *D-13,5* exhaust fan with a 55-kW electric motor and *VD-10* fan with a 22-kW electric motor The power margin of the exhaust fan is 250%, the power margin of the fan is 150% That was proved by the measurements made by means of the power factor meter TIF 2300 The power factor (cos φ) varied in the range of from 0 35 to 0 45 A large margin in the power factor results not only in the electric power overconsumption, but it does not allow to support the "fuel-to-air" ratio and the low pressure in the furnace if the thermal load of the boiler changed *DKVR 10/13* Boiler with the production capacity of up to 13 t/h operates only about 70% of the time in a year

It is proposed to mount at Boiler *DKVR-10/13* #4 an automatic system for controlling the "fuel-to-air" ratio and the low pressure in the furnace

The proposed system includes

1 Zirconium sensor of the oxygen content in the exhaust gases
2 Electronic controller
3 Speed-variable drives for the exhaust fan and for the fan
4 A transducer of the low pressure in the furnace
5 A transducer of pressure after the fan
6 A transducer of the pressure after the gas damper

In case of a change in the gas flow rate to the boiler, the flow rate of the air is changes automatically by changing the rotation speed of the fan with correcting the oxygen content in the exhaust gases At the same time there is automatically supported a constant low pressure in the furnace by changing the rotation speed of the exhaust fan

Calculation of a yearly saving of natural gas

1 Rising of the efficiency of the equipment (set according to the measurements data) — 4 0 %
2 The operation time utilization factor for the boiler per year (set) — 0 7
3 Yearly gas consumption at the plant (for 1997) — 7,196,000 m^3
4 Expected gas saving

$$7{,}196{,}000\ m^3 \cdot 0\ 04 \cdot 0\ 7 = 201{,}500\ m^3$$

Calculation of a yearly saving of electric power

1 Yearly electric power consumption by the boiler-house (for 1997) — 548,000 kW h
2 The amount of the electric power consumed by the exhaust fans and by the fans (set) — 30 %
3 Electric power consumption by the exhaust fan and by the fans at the operation time utilization factor equal to 0 7
548,000 kW h • 0 3 • 0 7 = 115,080 kW h
4 The expected decrease in the electric power consumption after introduction of a variable-speed drive (set from the operation experience) — 40 %
5 The expected saving 115,080 kW h • 0 4 = 46,032 kW h

Calculation of a early saving of costs

1 1,000 m^3 of gas cost USD 86 7
2 Saving of costs on gas 201,500 m^3 • USD 86 7 = USD 17,470
3 1 kW h costs USD 0 037
4 Saving of costs on electric power 46,032 kW h • USD 0 037 = USD 1,703
5 Total saving of costs USD 17,470 + USD 1,703 = USD 19,173

Commissioning costs

1 Zirconium oxygen sensor with taking into account the VAT and the customs fees (*Thermox Series Insitu Flue Gas Oxygen Analyzer*) — USD 4,000
2 The controller with taking into account the VAT and the customs fees (Model *348 Fieldpac*) — USD 3,700
3 The pressure sensors (2 units), Model *340 DXTC* — USD 3,000
4 *РЭН-22*-type speed-variable drives (2 units), N = 22 kW — USD 8,000
5 Designing, installation and commissioning works (set) — USD 3,000

Total costs USD 21,700

The simple payback period USD 21,700 USD 17,173 = 1 13 yr ≅ 14 months

ECO - 5 **Redesigning of *DKVR-6,5/13* Steam Boiler for water heating operation mode**

The plant has a water heating system that operated according to the temperature schedule of 95 to 70°C The heating load of the plant is about 53,000 Gcal per year, which is equivalent to about 780,000 m³ of natural gas There are 4 steam boilers installed in the boiler-house Heating of the delivery water is done in steam and water case-tube heaters not equipped with steam traps The current heat supply system is less efficient as compared it with the one where delivery water is heated in water heating boilers The Ukrainian operation experience has proved a high effectiveness of transferring *DKVR*-type steam boilers on the water heating operation mode, which allows to decrease the fuel consumption for the heating system by 25 to 30 per cent, as well as decrease the costs of repair works for the case-tube heaters, decrease electric power consumption by the delivery water pumps and to improve functioning of the heat supply system

It is proposed to redesign one of the three available *DKVR - 6,5/13* steam boilers for operating them in the water heating operation mode The boiler redesigning includes mounting partitions in the boiler drum, changing the water circulation in the economizer and in the furnace screens, changing the automatic control and protection system The thermal production capacity of the redesigned boiler will be 4 5 Gcal/hour, which will provide the thermal load of the heat supply system

Calculation of a yearly saving of natural gas

1 Improvement of the efficiency of the thermal scheme (set from the practice) — 25 %
2 Yearly gas consumption for the heat supply system (calculated for 1997) — 780,000 m³
3 Expected gas saving
780,000 m³ • 0 25 = 195,000 m³

Calculation of a yearly electric power saving

1 The power capacity of the delivery water pump (measured) — 25 kW
2 The number of the operation hours per year 26 weeks • 7 days • 24 hours = 4,368 hours
3 Yearly electric power consumption 4,368 hours • 25 kW = 109,200 kW h
4 The expected decrease in electric power consumption (from practice) — 15 %
4 The expected saving of electric power
109,200 kW h • 0 15 = 16,380 kW h

Calculation of a yearly saving of costs

1 1,000 m³ of gas cost USD 86 7
2 Saving on gas consumption 195,000 m³ • USD 86 7 = USD 16,906
3 1 kW h of electric power costs USD 0 037
4 Saving on electric power consumption 16,380 kW h • USD 0 037 = USD 606
5 The total saving USD 16,906 + USD 606 = USD 17,512

Commissioning costs

The cost of DKVR - 6,5/13 boiler redesigning on the "turnkey" basis — USD 16,500

The simple payback period USD 16,500 USD 17,512 = 0 94 year ≅ 11 months

ECO - 6 **Steam traps**

Description of the opportunity

According to the plant energy balance, the hot water supply system uses 2,880 Gcal of heat per year The steam and water heaters have no steam traps, which significantly worsens the efficiency of operation of the heaters, results in heat losses with he steam flash Besides, there are no steam traps after the following steam using items of the processing equipment

- calorifer of the inlet fans in the ancillary rooms block (1 unit),
- calorifer of the conditioner in the species drying room (1 unit),
- drying machines in the laundry room (5 units),
- cloths dryers (2 units) ——

The heat consumption by the said equipment, according to the balance, is 180 Gcal per year

Survey of the steam and condensate system and measurements of the temperature by means of *"Mikron"* infra-red thermometer showed that many steam traps in the thermal chambers do not operate properly, or they are absent at all Out of 24 steam traps 10 do not operate, 3 are absent The approximate thermal energy consumption by the sausage making workshop is about 8,000 Gcal per year

It is proposed to mount the lacking and to replace the faulty steam traps, which will increase the efficiency of steam using by the said items of the equipment by more than 15 per cent

Calculation of a yearly saving of natural gas

1 Yearly consumption of thermal energy by the fuel-and-air mixture heaters — 2,880 Gcal
2 Yearly consumption of thermal energy by the processing equipment — 180 Gcal
3 Yearly consumption of thermal energy by the thermal chambers at the operation time utilization factor equal to 0 3 8,000 Gcal • 0 3 = 2,400 Gcal
4 The total yearly consumption of thermal energy
2,880 Gcal + 180 Gcal + 2,400 Gcal = 5,460 Gcal
5 The expected decrease in the thermal energy consumption — 15 %
6 The expected saving of thermal energy 5,460 Gcal • 0 15 = 819 Gcal
7 The specific consumption of natural gas per 1 Gcal of the provided energy at the efficiency of the boiler-house equal to 85 % and at the lowest gas calorific value equal to 8,000 kcal/m^3
10^6 kcal (8,000 kcal/m^3 • 0 85) = 147 m^3/Gcal
8 Then expected saving of natural gas
819 Gcal • 147 m^3/Gcal = 120,400 m^3

Calculation of a yearly saving of costs

1 1,000 m^3 of gas cost USD 86 7
2 Saving on gas consumption 120,400 m^3 • USD 86 7 = USD 10,438

Commissioning costs

1 A steam trap assembly with a float steam trap (a strainer, a check valve)
- 40-mm diameter (2 assemblies) — USD 3,800,

- 25-mm diameter (2 assemblies) — USD 2,400

2 Thermodynamic steam traps with built-in filters

20-mm diameter (20 units) — USD 6,000

The total cost of the equipment — USD 12,200

The costs on the installations works (set as 30%) — USD 3,660

The total costs USD 12,200 + USD 3,660 = USD 15,860

<u>The simple payback period</u> USD 15,860 USD 10,438 = 1 5 years ≅ 18 months

ECO - 7 Steam and water mixing stations

Description of the opportunity

A peculiar feature about the meat processing plant is the necessity to wash every day the equipment, floors and walls in the rooms with hot water with the temperature of about 55 to 60°C The heat consumption for the hot water supply system is about 2,800 Gcal per year, from that, in accordance with the thermal energy balance for the plant about 50 per cent or 1,400 Gcal is used for washing The water consumption for that is about 28,000 m^3 per year Water is heated in the steam and water heater and supplied by pumps to the washing points The washing water hoses have no special stopping valves, which results in significant waste of water while the worker is moving from one working place to another

It is proposed to start operating steam and water mixing stations allowing to heat water by directly mixing steam and water and automatically support a set temperature The station equipment includes a "cap-pistol" that automatically stops water supply The proposed equipment will permit to decrease the stream consumption for washing and to decrease water consumption not less than by 30 per cent

Calculation of a yearly saving of natural gas

1 Yearly consumption of thermal energy for washing — 1,400 Gcal
2 The expected decrease in thermal energy consumption (set) — 30 %
3 The expected saving of thermal energy 1,400 Gcal • 0 3 = 420 Gcal
4 The specific consumption of natural gas per 1 Gcal of the supplied energy (calculation in ECO - 04) — 147 m^3/Gcal
5 Saving of natural gas 420 Gcal • 147 m^3/Gcal = 61,700 m^3

Calculation of a yearly saving of water and sewage

1 Yearly consumption of water for washing — 28,000 m^3
2 The expected decrease in water consumption (set) — 30%
3 Water saving 28,000 m^3 • 0 3 = 8,400 m^3
4 Saving of channelized sewage — 8,400 m^3

Calculation of a yearly saving of costs

1 1,000 m^3 of gas cost USD 86 7
2 Saving on gas consumption 61,700 m^3 • USD 86 7 = USD 5,350
3 1 m^3 of water costs USD 0 575
4 Saving on water consumption 8,400 m^3 • USD 0 575 = USD 4,830
5 1 m^3 of channelized sewage costs USD 0 535
6 Saving of the sewage costs 8,400 m^3 • USD 0 535 = USD 4,494
7 The total saving USD 5,350 + USD 4,830 + USD 4,494 = USD 14,674

Commissioning costs

1 The cost of a steam/water mixing station (the valve diameter is $^3/_4$, the steam pressure is 3 to 5 barg, the water pressure is 3 to 4 barg, the temperature range is from 40 to 90°C, the water flow rate id from 20 to 70 l/min) — USD 1,600
2 The proposed number of the points — 8

3 The cost of the equipment USD 1,600 • 8 = USD 12,800
4 The cost of the installation works and the cost of the ancillary equipment (set as 30%) — USD 3,840
5 The total costs USD 12,800 + USD 3,840 = USD 16,640

The simple payback period USD 16,640 USD 14,674 = 1 14 years ≅ 14 months

ECO - 8 **Control of the temperature schedule in the refrigerating and freezing chambers**

The plant uses every year about 7,700 Gcal of artificial cold, which requires 3 3 million kW h of electric power

The efficiency of operation of the refrigerating system depends a lot on the operation level of the freezing and refrigerating chambers

The measurements performed in the process of the audit showed a significant variation of temperature in different points in the chamber for example, from – 9°C to – 15°C in Chamber #12 (the area is 345 m²) and from – 15°C to – 23°C in Chamber #32 (the area is 730 m²) Inside the chambers incandescent lamps are constantly lit in Chamber #12 – 5 lamps of 100 W each, in Chamber #32 - 9 lamps of 100 W each The ceiling and floor registers of the evaporators are irregularly covered with ice if different thickness There are no plastic thermoinsulating curtains on the gates During the restoring operations there are "leaks" of the cold air and warm air from the atmosphere, that occurs through the open gates

No regular temperature registering is done in the refrigerating and freezing chambers, which does not allow to control and analyze their modes and undertake in due time measures aimed at supporting the maximum efficiency of their operation

It is proposed to equip each refrigerating chamber with a digital temperature recorder Availability of a temperature control will enable the following

- to assess the real situation in each chamber and to choose the most effective ones,
- to identify in due time degradation in their operation efficiency, analyze the reasons for that and undertake measures,
- to make more regular defrostation of the evaporators,
- to improve the operation level of the chambers and to optimize loading of the chambers,
- to estimate the implemented energy conservation opportunities and reach decreasing in the specific consumptions per unit of the products

On the basis of the practical experience of implementing a system for controlling and planning the energy costs, the expected saving of electric power consumption will be 5 to 8 per cent

Calculation of a yearly saving of electric power

1 Yearly consumption of electric power for production of cold — 3,266,100 kW h
2 The expected decrease in consumption of cold (set) — 6 5 %
3 Saving of electric power 3,266,100 kW h • 0 065 = 212,300 kW h

Calculation of a yearly saving of the costs

1 1 kW h of electric power costs USD $ 0 037
2 Saving of costs 212 300 kW h • USD 0 037 = USD 7 855

Commissioning costs

1 The cost of the Type 4 instrument (a recording thermometer from *Davis Instruments* - Catalog # *DK 266408*, Model *SL 4350C7* with a digital display, the temperature range is from –30 to + 50^{0}C) with the VAT and transpiration costs is USD 455

2 The required number of that sort of instruments — 15 units
3 The cost of the instruments USD 455 • 15 units = USD 6,825

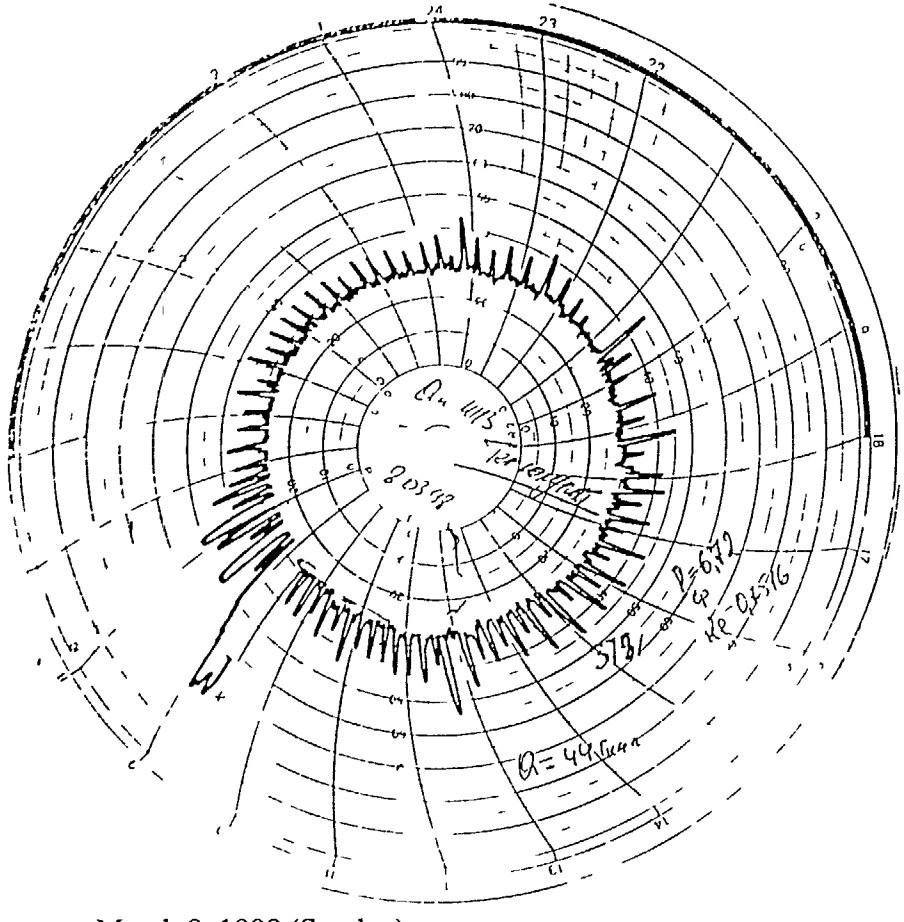
The simple payback period USD 6,825 USD 7,855 = 0 9 year ≅ 11 months

APPENDIX B MEASURED AND COLLECTED DATA

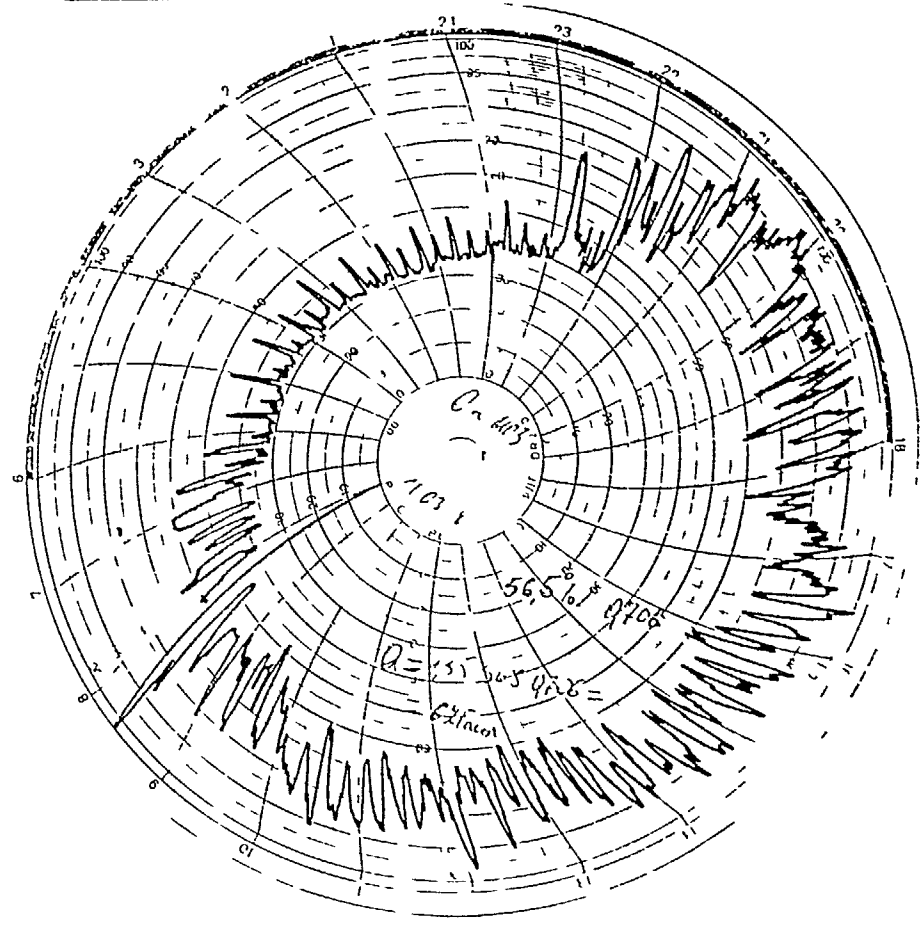
"Scheduling " the operation mode of the steam boilers *DKVR 6,5/13* No 3 and *DKVR 10/13* No 4 from 17 to 19 March 1998

DKVR 6,5/13 Boiler #3 (before adjustment)	*DKVR 6,5/13* Boiler #3 (after adjustment)	*DKVR 10/13* Boiler # 4 (before adjustment)	*DKVR 10/13* Boiler # 4 (after adjustment)
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 513	SER NO VCO 513	SER NO VCO 513	SER NO VCO 513
TIME 15 06	TIME 09 31	TIME 15 27	TIME 14 40
DATE 18, 03, 98	DATE 19, 03, 98	DATE 17, 03, 98	DATE 18, 03, 98
FUEL NATURAL GAS	FUEL NATURAL GAS	FUEL NATURAL GAS	FUEL NATURAL GAS
PRIMRY TEMP <C>26	PRIMRY TEMP <C>22	PRIMRY TEMP <C>20	PRIMRY TEMP <C>37
STACK TEMP <C>179	STACK TEMP <C>179	STACK TEMP <C>164	STACK TEMP <C>164
% OXYGEN 10 9	% OXYGEN 9,5	% OXYGEN 13,1	% OXYGEN 10 5
% EXCESS AIR 99	% EXCESS AIR 76	% EXCESS AIR 153	% EXCESS AIR 92
% CARBON - DIOXIDE 5,6	% CARBON - DIOXIDE 6,4	% CARBON - DIOXIDE 4,4	% CARBON - DIOXIDE 5,8
PPM CARBON - MONOXIDE 4	PPM CARBON - MONOXIDE 4	PPM CARBON - MONOXIDE 0	PPM CARBON - MONOXIDE 3
PPM MOX 91	PPM MOX 134	PPM MOX 58	PPM MOX 91
PPM SULFUR - DIOXIDE 13	PPM SULFUR - DIOXIDE 15	PPM SULFUR - DIOXIDE 6	PPM SULFUR - DIOXIDE 12
% EFFICIENCY 88,7	% EFFICIENCY 89,6	% EFFICIENCY 86,7	% EFFICIENCY 90,8
% STACK LOSS 11,3	% STACK LOSS 10,4	% STACK LOSS 13,3	% STACK LOSS 9,2
TEST PERFORMED BY	TEST PERFORMED BY	TEST PERFORMED BY	TEST PERFORMED BY

Steam consumption schedule for the basic production line during 24 hours



March 8, 1998 (Sunday)
Production output - 0 tonne
Heat consumption - 44 Gcal
Steam pressure - 6 7 barg



March 11, 1998
Production output - 13 1 tonnes
Heat consumption 62 Gcal
Steam pressure

APPENDIX C PHOTOGTAPHS OF THE PLANT

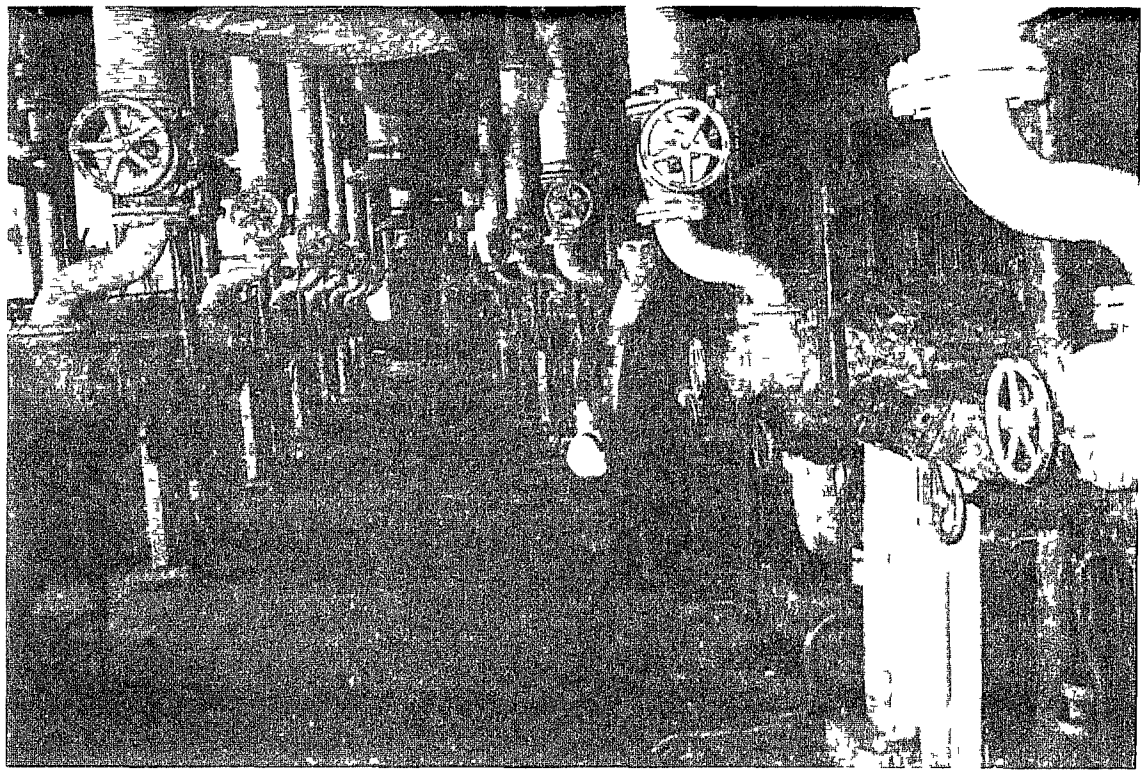


Фото 1 Компрессорная станция завода
Photo 1 Compressor station of the enterprise

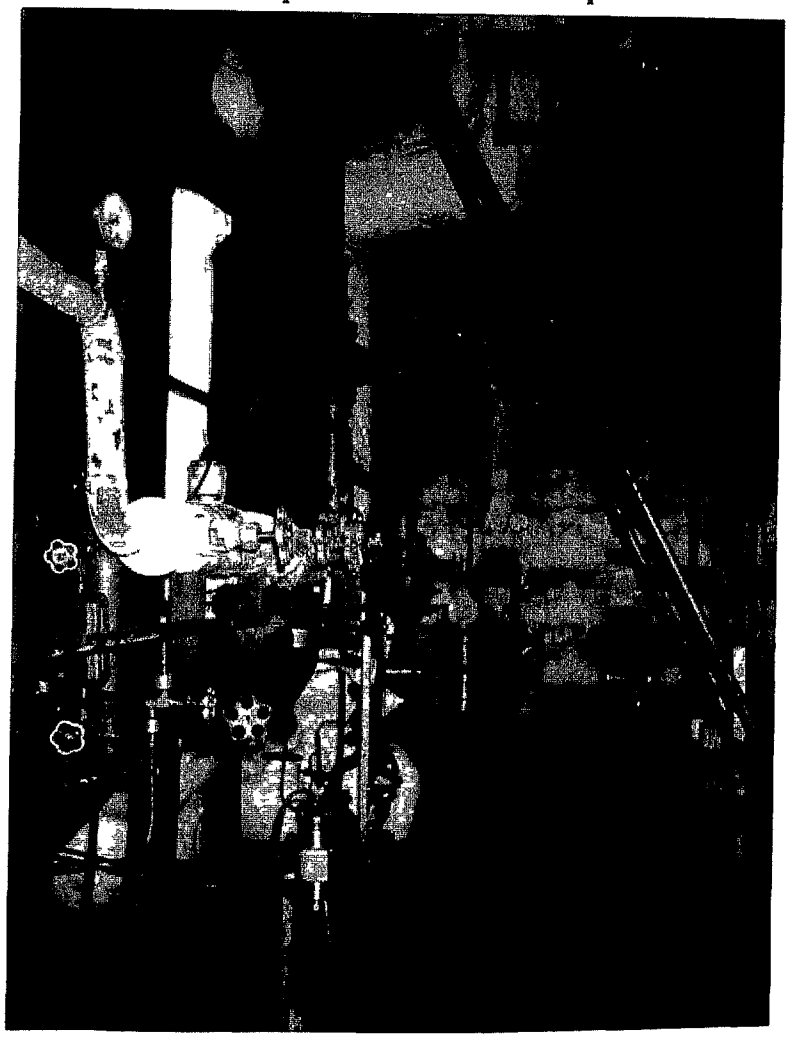


Фото 2 Распределительная гребенка подачи аммиака в морозильные камеры
Photo 2 Distributing manifold for ammonium supply into the freezing chambers

Фото 3 Исследование распределения температур в холодильной камере
Photo 3 Study of the temperature distribution in a freezing chamber

Фото 4 Обсуждение предварительных результатов с руководством завода
Photo 4 Discussion of the preliminary results with the enterprise management

APPENDIX D CONVERSION FACTORS

CURRENCY EQUIVALENTS

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

CONVERSION FACTORS

HEAT

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

POWER

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

PRESSURE

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

LENGTH UNITS

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

WEIGHT UNITS

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

AREA UNITS

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

VOLUME UNITS

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

HEAT CONTENT

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

TEMPERATURE

°C = 0 56 (°F – 32)

APPENDIX E ABBREVIATIONS

ABBREVIATIONS

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

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