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Delivery Order No 30
Industrial Energy Efficiency - Ukraine
April 1998

REPORT
ON ENERGY AUDIT
AT COLLECTIVE COMPANY

"KHMELNYTSKYI CONFECTIONERY"

Khmelnytskyi City, Ukraine

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1 0 EXECUTIVE SUMMARY

1 1 Introduction

As part of Delivery Order No 30, Industrial Energy Efficiency - Ukraine, the U S Agency for International Development (USAID) sponsored energy efficiency audits at 24 industrial plants that met the criteria and were approved by USAID The purpose of the project was to develop Ukrainian energy service company (ESCO) capabilities To accomplish this task, *Burns and Roe Enterprises, Inc* (the primer contractor) hired Ukrainian engineers These engineers were trained in U S techniques of conducting energy audits and in ESCO concepts The industrial energy audits were conducted to facilitate the ESCO training

This report details the findings of Burns and Roe Enterprises, Inc , energy audit performed at the Collective Company *Khmelnytskyi Confectionary* located in the city of Khmelnytskyi, Ukraine The Collective Company *Khmelnytskyi Confectionary* is modern enterprise and is one of the largest in its field in Ukraine

The project team consisting of two representatives of the American company **Burns and Roe Enterprise, Inc** , energy management experts Mr Viktor Svistunov and Mr Vladimir Prokopenko, performed the energy audit during April 12 to 18, 1998 trip to the site Having fulfilled its objectives, the project team prepared the following report

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

1 2 Principal Findings

1 A group of energy auditors between April 12 - 18, 1998 performed an energy audit at the Collective Company "*Khmelnytskyi Confectionery*"

2 The basic products at *Khmelnytskyi Confectionery* are chocolates, caramels, toffee, dragee, waffles with staffing, etc

3 In the period between 1995 and 1997 the production output of the basic products increased from 6,937 tonnes to 8,014 tonnes

4 The enterprise has its own sources of providing thermal energy, cold energy as well as its own basic and ancillary production facilities providing a completed production cycle

5 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 tom1 year) that do not require high costs, and middle-term payback periods (up to 2 years) requiring noticeable capital investments

6 The total annual energy saving after implementation of the proposed measures will be(without taking into consideration interaction of the projects) as follows

- saving of electric power - 113,000 kW h,
- saving of natural gas - 629,900 m^3,

- saving of water - 19,800 m^3

7 The energy costs saving is US $71,900 per year, and the costs of the measures to be implemented being US $109,300 At the same time there will be attained decreasing of emissions into the environment of harmful substances (CO, SO_2, NO_x ash) by 3 2 tonnes per year

8 After the plant has chosen the priorities concerning implementation of ECOs when making the financial estimation of a measure, interaction of the projects must be taken into consideration

9 The plant has got reserves for further energy saving improvement, implementation of which requires a more detailed energy audit

1 3 Recommendations

Table 1 1 (see the next page) lists the energy conservation opportunities (ECOs) identified for the facility, as well as estimated energy savings and cost savings and the simple payback periods The majority of the opportunities have the simple payback period of one year or less For example?
ECO #1 - "Establishment of energy management system" will enable regular work aimed at energy saving and creation of energy management department The latter will be responsible for controlling and analyzing the energy consumption at the plant, as well as for development of recommendations and a reconstruction plant or for improvement of any system that can lead to energy savings
To 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
automation of the system for metering consumption of natural gas (**ECO #2**),
improvement of the efficiency of the thermal energy utilization (**ECOs #3, 4, 5, 6 and 8**),
utilization of the heat of the exhaust gases from the steam boiler ***DKVR-4/13*** (**ECO #7**)

Measures with a short payback period (**ECO #4, 6**) are recommended for implementation in the first turn While financial conditions are getting better, the plant management should consider the issue of implementation of the other measures (**ECOs #2, 3, 5, 7 and 8**)

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Table 1 1

List of Energy Conservation Opportunities (ECOs)

ECO	Description	Saving			Cost of the energy saving, USD	Project costs, US $	Payback period, year
		Electric power, 1,000 kW h	Natural gas, 1,000 m^3	Water, 1,000 m^3			
1	Establishment of energy management system	113	130	13	18,782	27,892	1 5
2	Automatization of the system for the natural gas consumption metering		116 3		9,653	15,000	1 6
3	Temperature controlling valves		14 3		1,187	1,800	1 5
4	Steam traps		21 4		1,776	1,400	0 8
5	Transfer of the heat supply system from steam on hot water		73 0		12,109	13,500	1 1
6	Utilization of the heat from the contiguous blowing the steam boilers		11 4		1,936	1,700	0 9
7	Utilization of the heat from of the exhaust gases from the *DKVR-4/13* Boiler		62	2	5,146	5,450	1 1
8	Modernization of the steam and condensate system		201 5	4,8	21,305	42,550	2
	Total	**113**	**629 9**	**19 8**	**71,894**	**109,292**	**1 5**

2 0 GENERAL BACKGROUND

Director General Mr Vasyl Stanislavovych Liubovetskyi
Chief Engineer Mr Viktor Stepanovych Kostyshko

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69, Shevchenko,
Khmelnitskyi, 280000,
Ukraine

2 1 History of Plant

Khmelnytskyi Confectionery was founded in 1928 with the yearly production output of 6,000 tonnes of confectionery products In 1968 the enterprise was reconstructed, which made it possible to increase the production output to 17,000 tonnes of confectionery products per year In 1993 the enterprise was reorganized into the Collective Company *"Khmelnytskyi Confectionery"* The basic processing units at the enterprise are as follows

- a caramel workshop,
- packaged candy-production workshop,
- a waffle production area,
- retail-purposed candy production workshop,
- varying-sort candy production workshop,
- a preparatory area,
- a compressor-and-cooling workshop,
- other plant units

2 2 Types of products

The enterprise produces confectionery chocolates, caramels, toffees, dragee, waffles with filling, etc

At the plant there is in progress upgrading of the production lines aimed at widening the assortment of the finished products The plant has a set of specialized shops

2 3 Number of employees

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 25 Food industry and improvement of the efficiency of energy utilization in this branch is very important for the population and economy of Ukraine

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3 0 CURRENT STATUS OF PRODUCTION

3 1 Maximum estimated production capacity of plant

The maximum production capacity of the plant is about 12,000 tonnes per year

3 2 Real production capacity of plant

In 1995 - 1997 the plant operated not in its full capacity as the sale market was reduced

It is possible for the enterprise to increase the production level to the designed value providing availability of a sale market

The production levels in 1995 - 1997

Table 1

Products	Production level, tonne			Note
	1995	1996	1997	
1 Confectionery products	6,937	6,800	8,014	The products of flour including

Production output in 1997

Table 2

Month	Production level, tonne		
	Sugar products	Flour products	Total
January	626	53	679
February	629	59	688
March	653	59	712
April	543	87	630
May	594	67	661
June	557	87	644
July	554	118	672
August	251	97	348
September	502	71	573
October	742	80	822
November	601	68	669
December	815	101	916
Total in 1997	**7,067**	**947**	**8,014**

5

Production of the basic sorts of products in 1997

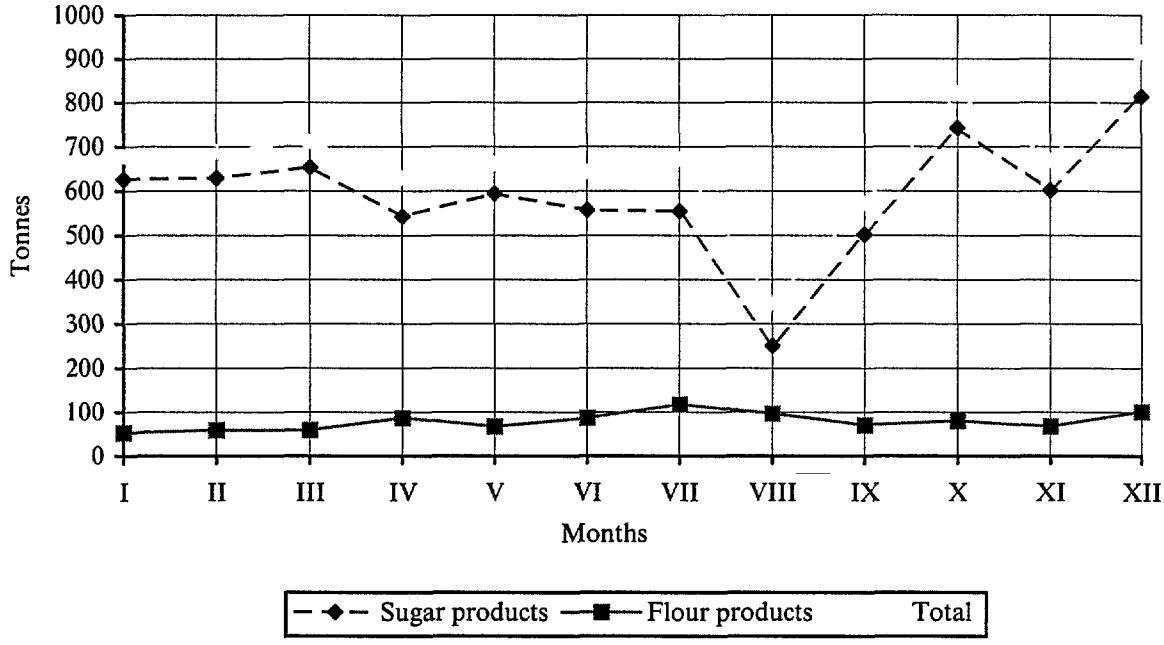

Fig 1

The production output is instable during a year with some rising by the end of the year, which is accounted for by rising of the demand Decline in the production level in August is accounted for by the repair of the equipment in the caramel workshop

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 10- 12 thousand tonnes per year

3 4 Export vs Domestic production

According to the data for 1997, about 40% of the total production output were exported

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4 0 FINANCIAL STATUS OF PLANT

4 1 Currency vs Barter

Barter operations in 1997 were 8 to 9 per cent

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 List of the basic processing operations

1 A mechanized conveyer line for production of caramel with filling
2 A mechanized conveyer line for production of candy glasses and of praline candies
3 A toffee production line
4 A mechanized conveyer line for production of cast candies
5 A mechanized conveyer line for production of praline candies
6 A mechanized conveyer line for production of waffles
7 A meteorite line
8 A line for nougat candies deposition
9 A line for casting candies
10 A line for production of whipped candies
11 Chocolate production line

5 2 Basic energy consuming equipment

Electric power (the installed capacity of the equipment)

1 The caramel production workshop (boiling tanks, temperers, candy-glass machine, caramel machine, toffee machine, etc) — N = 252 kW
2 The packaged candies production workshop (boiling tanks, basic processing production lines, etc) — N = 189 kW
3 The waffle production area (temperers, furnaces, mills, pumps, etc) — N = 134 kW
4 The retail-purpose candies production workshop (temperers, basic processing lines, pumps, etc) — N = 89 kW
5 The varying-sort candies production workshop (temperers, basic processing lines, whippers, etc) — N = 81 kW
6 Preparatory area (mills, filling mixers, pumps, etc) — N = 257 kW
7 The boiler-house (pumps, ventilators, exhaust fans, etc) — N = 144 kW
8 The compressor-and-cooling workshop (air and cooling compressors, pumps, etc) — N = 293 kW
9 Ventilation system — N = 105 kW
10 Pupm station — N = 83 kW

Thermal energy (steam)

1 Processing needs

1 1 Boiling tanks	— 10 tanks
1 2 Tenperers	— 10 machines
1 3 Boiling columns	— 4 columns
1 4 Vacuum-apparatus	— 4 units
1 5 Heaters (coiled)	— 15 heaters
1 6 Drying cabinets	— 3 cabinets
1 7 Water heaters	— 7 heaters

2 *Steam heat supply system* (radiators, registers)

3 *Hot water supply system* (steam-and-water heaters)

4 *Natural gas*

4 1 *DKVR*- 4 / 13 steam boilers with the production capacity of 4 tonnes per hour — 2 units

4 2 *G-30* Waffle furnaces — 3 units

5 3 Current tariffs on energy resources in 1998

1,000 m³ of natural gas cost	— US $83 (without VAT)
1 kW h of electric power cost	— US $0 043
1 m³ of drinking water costs	— US $0 24 (without VAT)
1 m³ of waste water costs	— US $0 196 (without VAT)

5 4 Metering consumption of energy resources

Commercial metering of the consumption of natural gas supplied to the factory is provided by means of meters of *RG*- 640 (the boiler-house), *RG*-250 (the waffle production workshop) and *RG*-40 (drying) types

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 and thermal energy is determined by calculation on the basis of the plant specific consumption rates

5 5 Structure of energy consumption and its cost in 1997

Khmelnytskyi Confectionery uses for its processing needs electric power, natural gas and drinking water In 1997 there was consumed about 1 51 million kW h of electric power that cost about

US $64,900, about 1 74 million m³ of natural gas that cost US $144,300, about 173,600 m³ of water that cost US $41,700

The structure of energy consumption and its costs is shown in Table 3 and in Fig 2 to 3 The costs on the energy resources for the needs of the plant itself were respectively as follows natural gas – 58 per *Khmelnytsky Confectionery* uses for its processing needs electric power, natural gas and drinking water cent, electric power – 26 per cent, water – 16 percent of the total energy costs

Table 3

The structure of the total energy use and its costs

Energy resource	Consumption	Gcal	Percentage	Cost, USD	Percentage
Natural gas	1,739,000 m³	14,069	92	144,337	58
Electric power	1,510,000 kW h	1,299	8	64,930	26
Water	173,600 m³	—	—	41,664	16
Total	—	15,368	100	250,931	100

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Energy balance

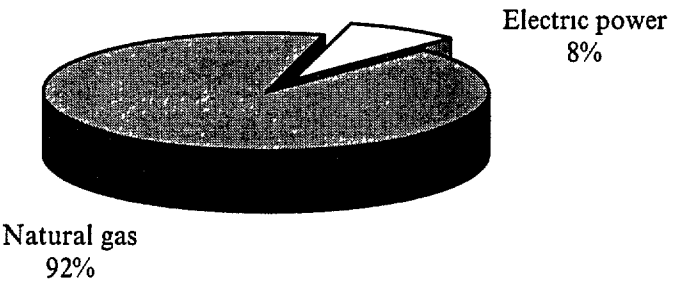

Fig 2

Balance of costs

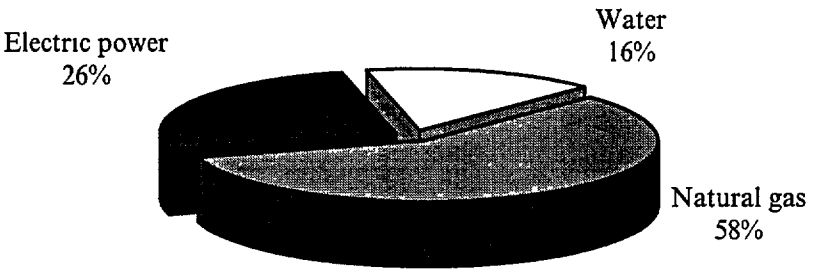

Fig 3

Note Data for the calculation

1,000 m³ = 8 09 Gcal 1,000 m³ of natural gas — US $83
1,000 kW h = 0 86 Gcal 1,000 kW h — US $43
1,000 m³ of water — US $240

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, (kW h x 10³)

Table 4

Months												
I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	**Total**
Total consumption												
123 6	131 4	123 8	93	126 6	125 8	128 4	81 1	127 9	147 5	149 5	150 9	**1,510**

5 6 2 Consumption of electric power in 1997 (kW h x 10^3)

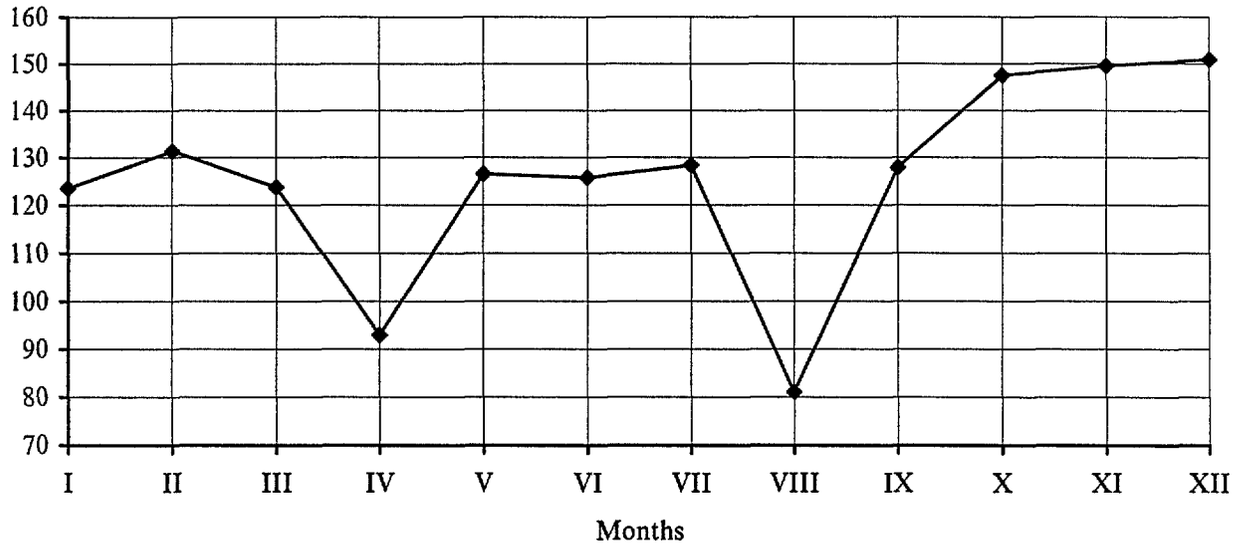

Fig 4

Electric energy consumption during a year is mainly determined by the production output The ratio between the decline of the production and energy depends on the sort of the products

In April decline in the production output in by 17 per cent was accompanied by a 25- per cent of the decrease in the energy consumption, while in August the decrease in the production level by 55 per cent caused decreasing the costs of energy resources equal to 37 per cent No detailed analysis in the process of the energy audit was done

The basic electric power users are

- Caramel, packaged sweets and waffles production workshops,
- Compressor-and-cooling workshops,
- Boiler-house,
- Retail-purposed candies and varying-sorts candies production workshops,
- Other units

Approximate distribution in electric power consumption between the basic production units and areas

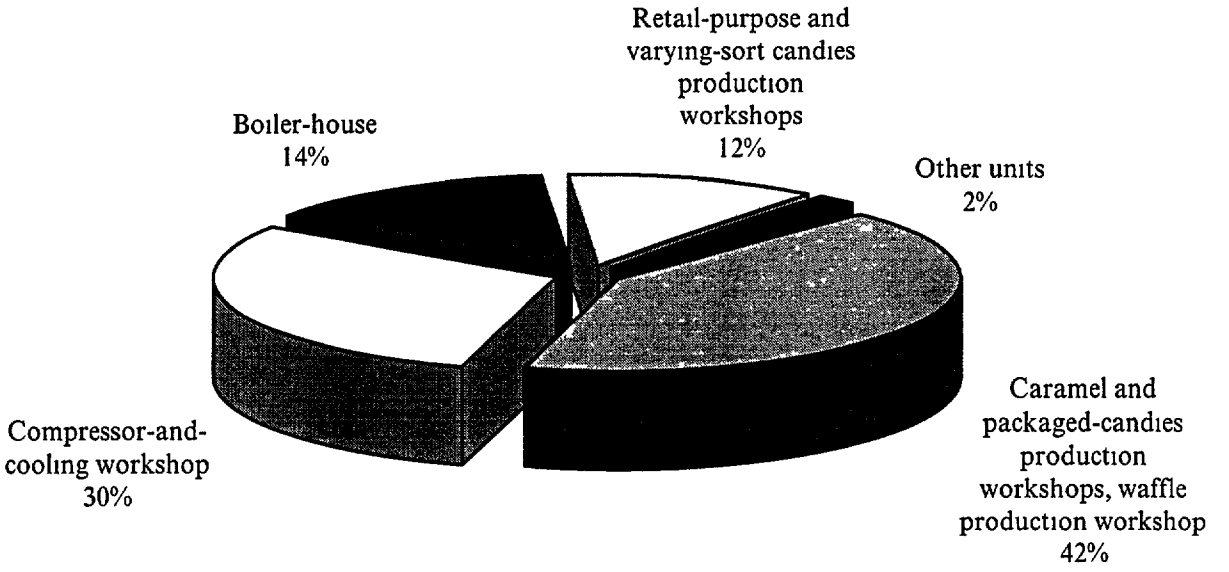

Fig 5

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

Table 5

Months												
I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	**Total**
Total consumption												
183 8	228 5	138 5	140 5	91 7	137 8	120 4	84 3	120 2	154 7	153 6	184 8	**1,739**
Boiler-house												
169 3	208 4	125 5	121 4	84 0	118 8	101 7	65 9	106 0	141 6	139 6	169 0	**1,551**
Waffle production area												
14 5	20 1	13 0	19 1	7 7	19 0	18 7	18 4	14 2	13 1	14 0	15 8	**188**

Consumption of natural gas

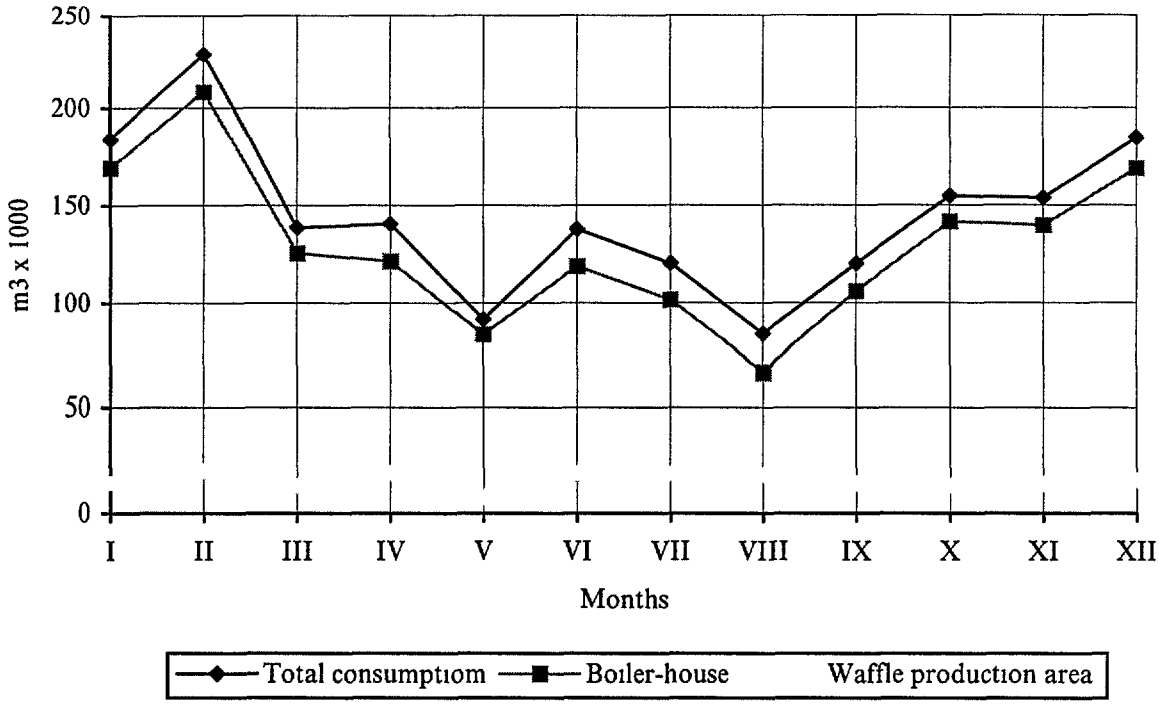

Fig 6

The amount of the natural gas consumption is not stable during a year and it has a seasonal character Gas is burnt in the boiler-house to generate steam that is used for the processing needs, to heat water for hot water supply and in the heat supply system The heat load rises in the winter period, and it takes about 20 per cent of the total energy consumption to cover that consumption

Distribution of natural gas between the basic production units

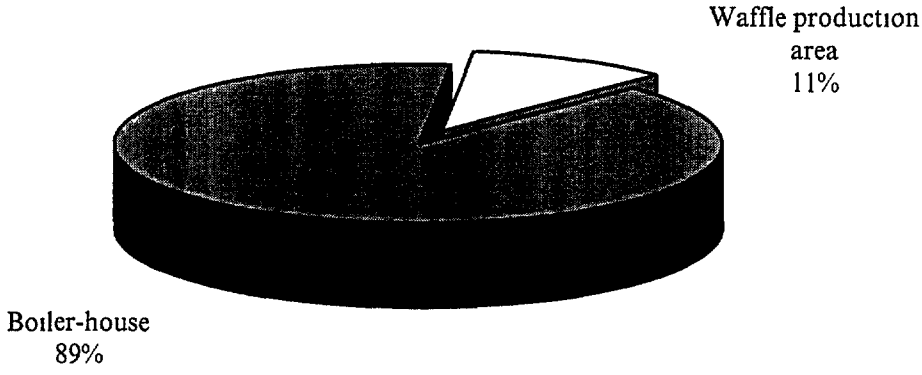

Fig 7

5 6 3 Drinking water, m³

Table 7

Months												
I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	**Total**
Total consumption												
17 2	16 1	13 4	12 2	11 5	13 4	17 4	13 4	13 0	15 7	13 5	16 8	**174**

Consumption of drinking water

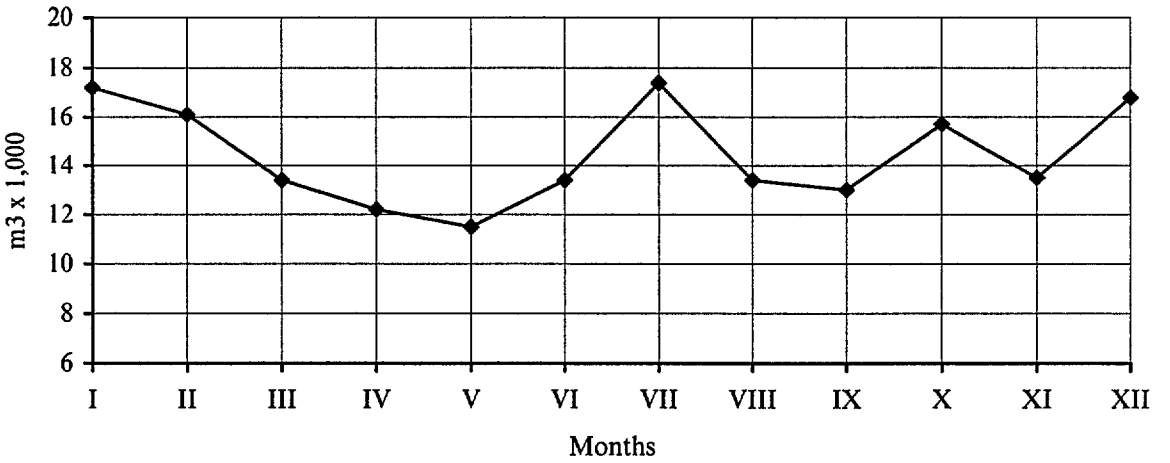

Fig 8

Water consumption depends on the season (heating load) and on the production output Increasing of consumption in July is accounted for by washing the equipment before starting the repair works in the caramel workshop

The main water consumers are

- Caramel production workshop, packaged candies production workshop, waffle production area,
- Compressor-and-cooling workshop,
- Boiler-house,
- Retail-purpose candy production workshop and the varying-sort candies production,
- Others

The main reserves in water saving are the following ones

- increasing the portion of the condensate returned to the boiler-house,
- improvement of the efficiency of the circular water supply to the compressor-and-cooling workshop,
- decreasing the costs on cooling the water blown in the boiler-house

Approximate distribution of water between the basic plant units

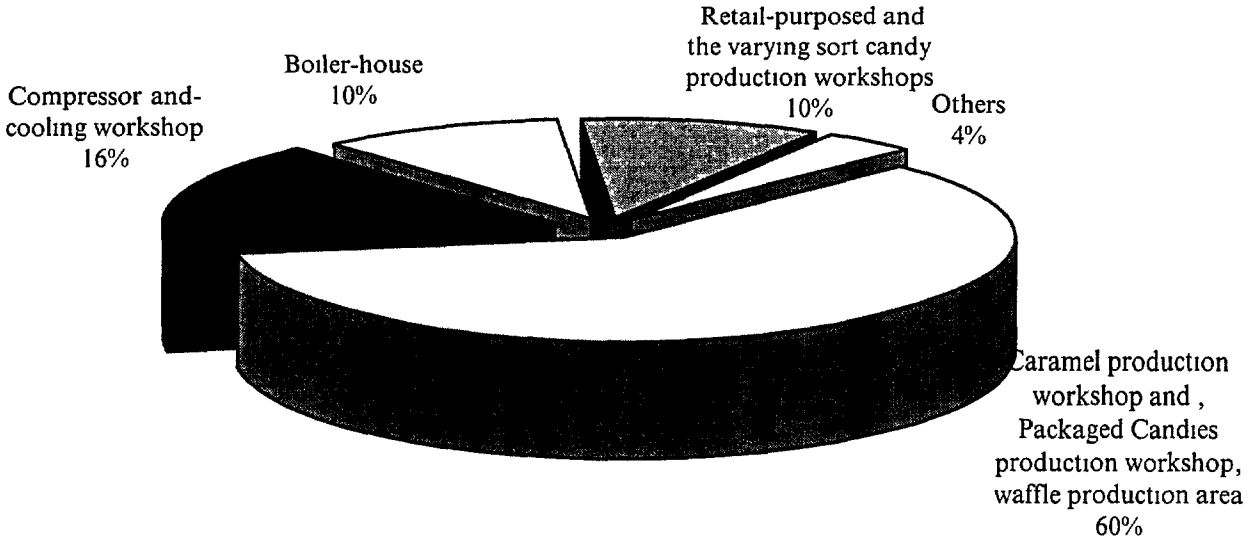

Fig 9

5 6 4 *Thermal energy*

As at the boiler-house there is no metering the consumption of the produced steam and as at the factory there is no steam and condensate balance, the generation of the thermal energy in 1997 was determined by calculation on the basis of the following indicators

- the average gross efficiency of the boilers (according to the evaluation tests during the audit) — 91 %,
- the lowest calirific value of the fuel — 8,090 kcal/m^3 (data from factory)

The specific gas consumption per generation of 1 Gcal of heat

$$\frac{10^6 \text{ kcal}}{8{,}090 \ \text{kcal}/\text{m}^3 \bullet 091} = 136 \ \text{m}^3$$

Table 8

Months												
I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	**Total**
Total heat production, Gcal (calculated value)												
1,245	1,532	923	893	618	874	748	485	779	1,041	1,026	1,243	**11,407**

To estimate the efficiency of operation of the boiler-house and the efficiency of the thermal energy utilization more precisely and objectively, it is reasonable to perform modernization of the existing

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assembly for metering the steam consumption and to organize automatical metering of the provided thermal energy

Production of thermal energy in 1997

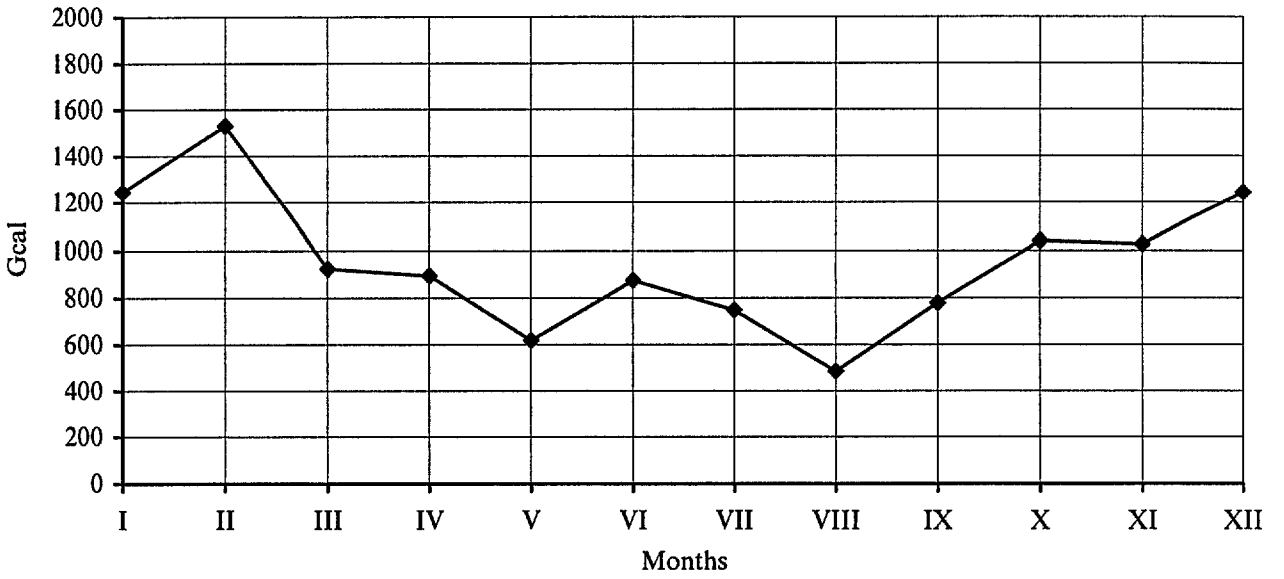

Fig 10

The thermal energy production level is not stable during a year and has a clear seasonal character It is determined by availability of the heating load, production needs and providing heat to off-factory users

Approximately, thermal energy is distributed in the following way

- Processing needs — 65 to 67 %
- Heating — 18 to 20 %
- Hot water supply — 8 to 10 %
- Losses on some needs in the boiler-house directly — 4 to 6 %
- Other users — 1 to 2 %

Distribution of thermal energy consumption between the basic units of the factory

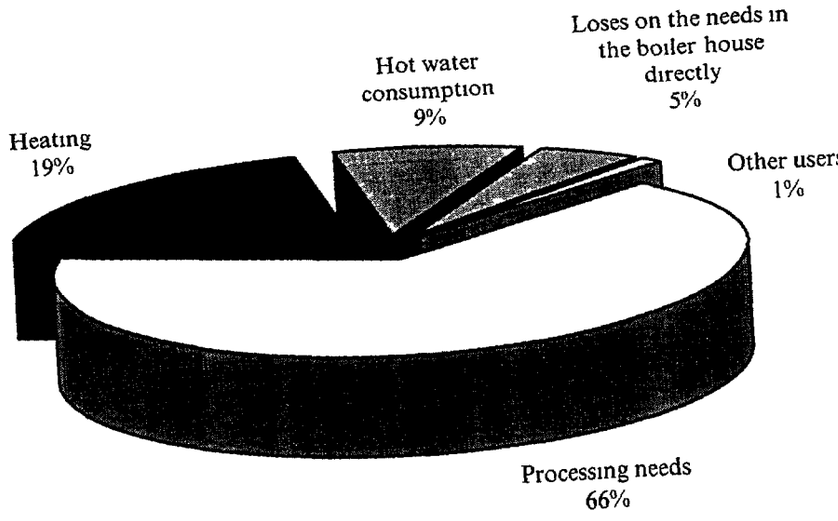

Fig 11

As it is seen from the balance of distribution of the thermal energy shown on the basis of the data for 1997, the main direction in energy conservation is improvement of the efficiency of operation of the processing equipment, hot water supply and heat supply systems

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6 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, tonne	Electric power		Natural gas		Drinking water	
		kW h	kW h/t	m^3	m^3/t	m^3	m^3/t
January	679	123,600	182 0	183,800	270 7	17,200	25 3
February	688	131,400	191 0	228,500	332 1	16,000	23 4
March	712	123,800	173 9	138,500	194 5	13,400	18 8
April	630	93,000	147 6	140,500	223 0	12,200	19 4
May	661	126,600	191 5	91,700	138 7	11,500	17 4
June	644	125,800	195 3	137,800	214 0	13,400	20 8
July	672	128,400	191 1	120,400	179 2	17,400	25 9
August	348	81,100	233 0	84,300	242 2	13,400	38 5
September	573	127,900	223 2	120,200	209 8	13,000	22 7
October	822	147,000	179 4	154,700	188 2	15,000	19 1
November	669	149,500	223 5	153,600	229 6	13,500	20 2
December	916	150,900	164 7	184,800	201 7	16,800	18 3
Total	**8,014**	**1,510,000**	**188 4**	**1,739,000**	**217 0**	**173,800**	**21 7**

Specific consumption of electric power

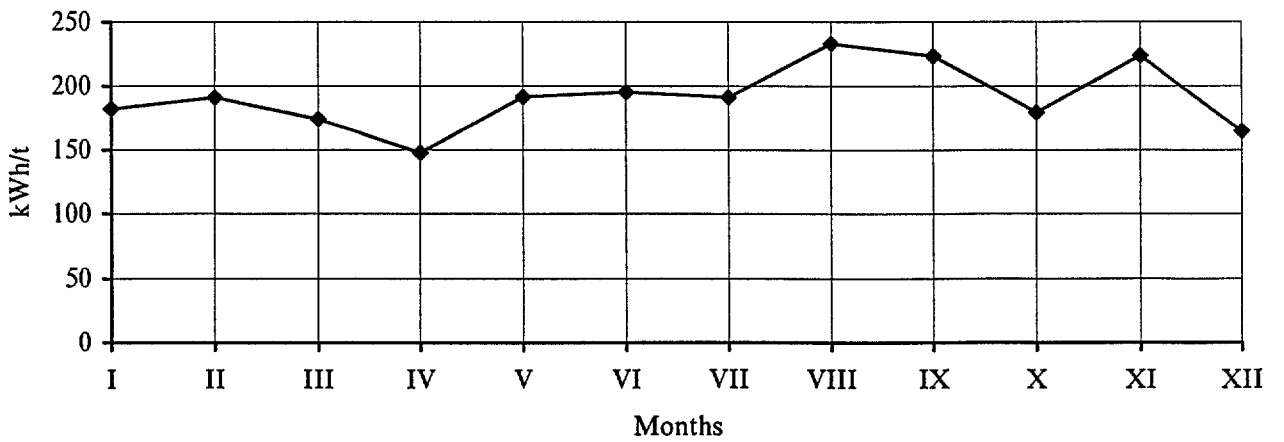


Fig 12

18

Specific consumption of natural gas

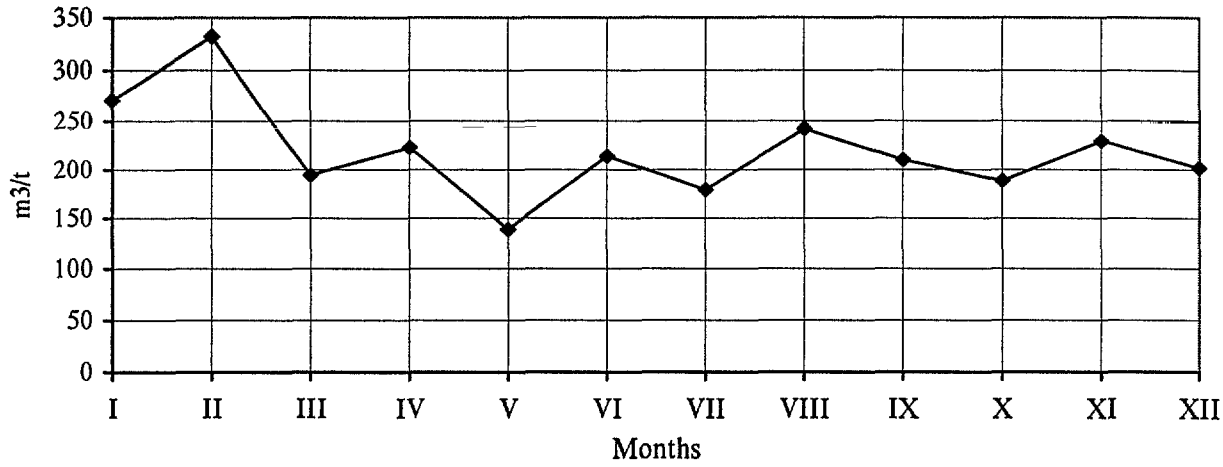
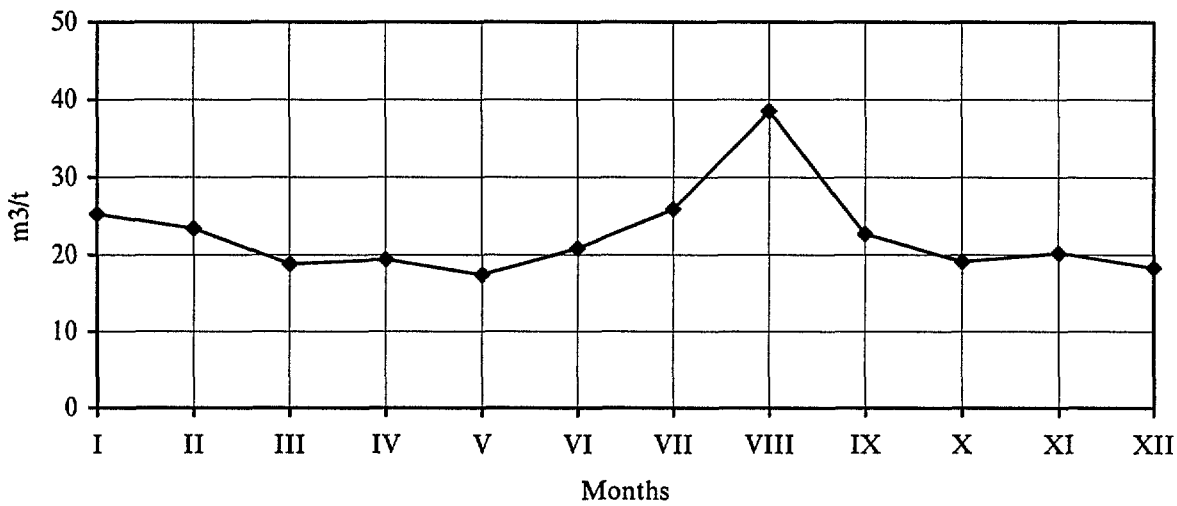


Fig 13

Specific consumption of drinking water



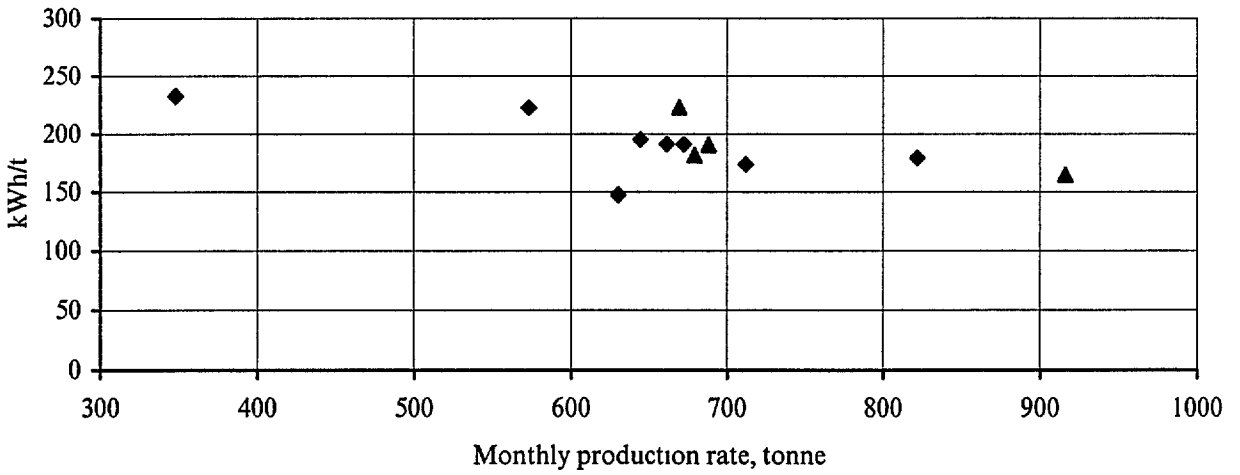
Fig, 14

In 1997 at the average production rate of the basic products in 688 tonnes per month (32 tonnes per day) the specific energy consumption was as following

- electric power — 188 kW h/t (148 to 233 kW h/t),
- natural gas — 217 m^3/t (139 to 332 m^3/t),
- water — 21 7 m^3/t (18 to 38 m^3/t)

To receive a more precise estimation, Fig 15 and 16 show specific energy consumptions per 1 tonne of products versus the monthly production level

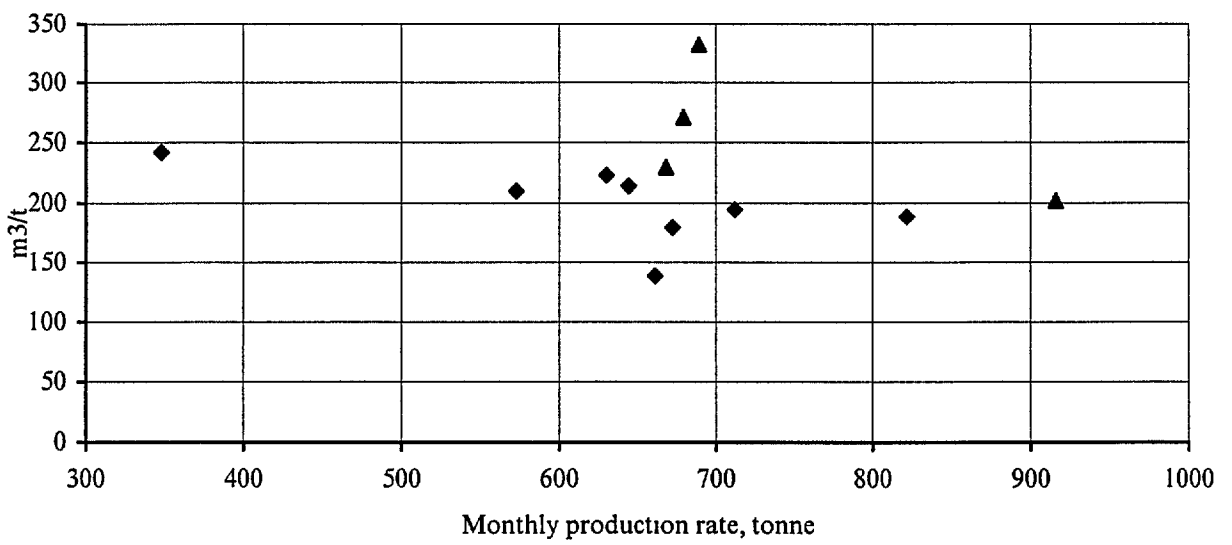
Specific consumption of electric power versus the production level



Note ▲ — winter period

Fig 15

Specific consumption of natural gas versus the production level



Note ▲ — winter period

Fig 16

As it can be seen from Fig, 15 and 16, the specific consumptions of electric power and natural gas depend on the production output The specific consumption of electric power practically does not depend on the season, the specific consumption of natural gas per 1 tonne of the products in the winter period increases by 25 to 30 per cent, which is accounted for by consumption for the heating purposes When introducing the system fort controlling and planning the energy costs the energy manager of the factory should take into consideration this factor

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6 2 Analysis of the factory operation during March - 2 - 25, 1998

Analysis of the plant operation during March 2 - 25, 1998 and of consumption of natural gas in that period allows to estimate the specific consumption of natural gas separately for the production area for sugar products and for the production area for the flour confectionery versus the daily productivity of the factory and the regime of its operation

The results are given in Tableas 10 and 11 and in Fig 17 to 24

Table 10

Day	Production of sugar products, tonne	Consumption of natural gas in the boiler-house, m^3	Specific gas consumption per 1 tonne of sugar confectionery, m^3/tonne
2 03	26 69	2,503	94
3 03	30 09	6,558	218
4 03	32 79	5,801	177
5 03	32 96	5,983	182
6 03	31 46	4,341	138
7 03	0	0	0
8 03	0	0	0
9 03	30 28	6,564	217
10 03	23 34	6,300	270
11 03	27 14	5,286	195
12 03	28 43	6,087	214
13 03	47 24	6,154	130
14 03	0	6,115	0
15 03	0	0	0
16 03	27 44	5,030	183
17 03	27 41	6,423	234
18 03	25 75	6,015	234
19 03	29,01	6,485	224
20 03	48 15	6,103	127
21 03	0	5,819	0
22 03	0	0	0
23 03	24	6,320	263
24 03	23 49	5,929	252
25 03	22 92	6,848	299
Total	**608 5**	**116,665**	**191 7**

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Production of sugar confectionary

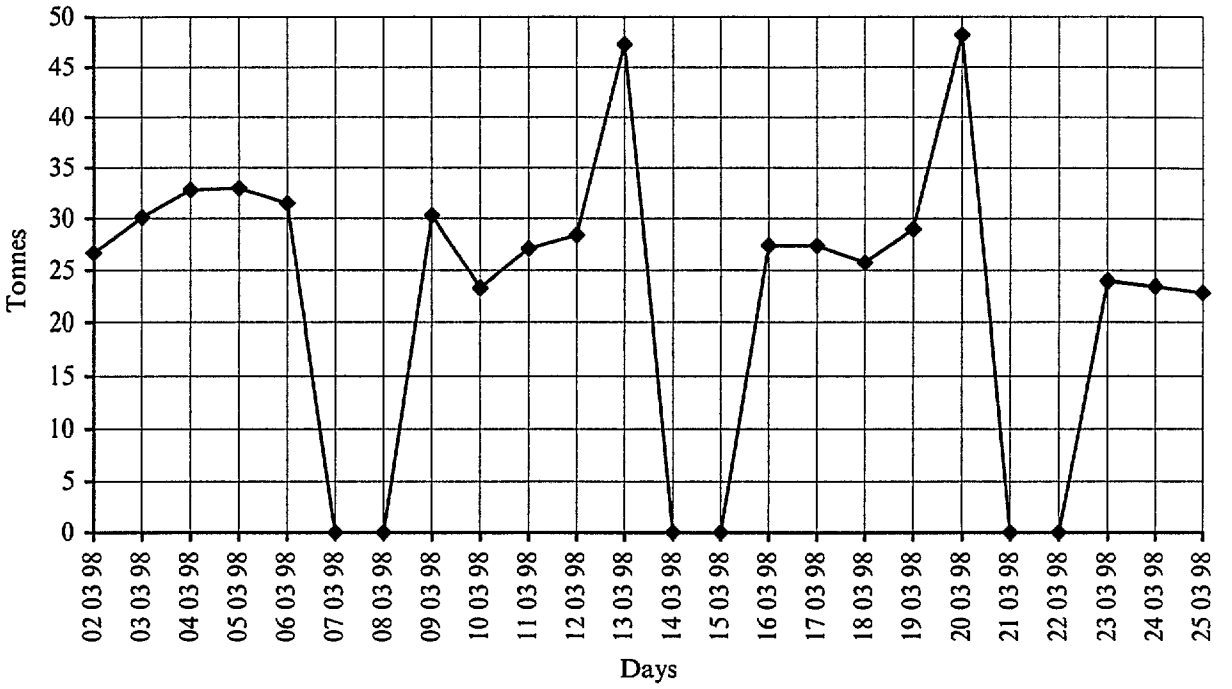

Fig 17

The factory works 5 days a week Rising of the production output on Fridays March 13 and 20 is conventional, as at the end of the week remnants of the products produced earlier and not sent to the stock were received there Sop, these days were excluded from the analysis of the specific consumption of gas per 1 tonne of the products

Consumption of natural gas in the boiler-house

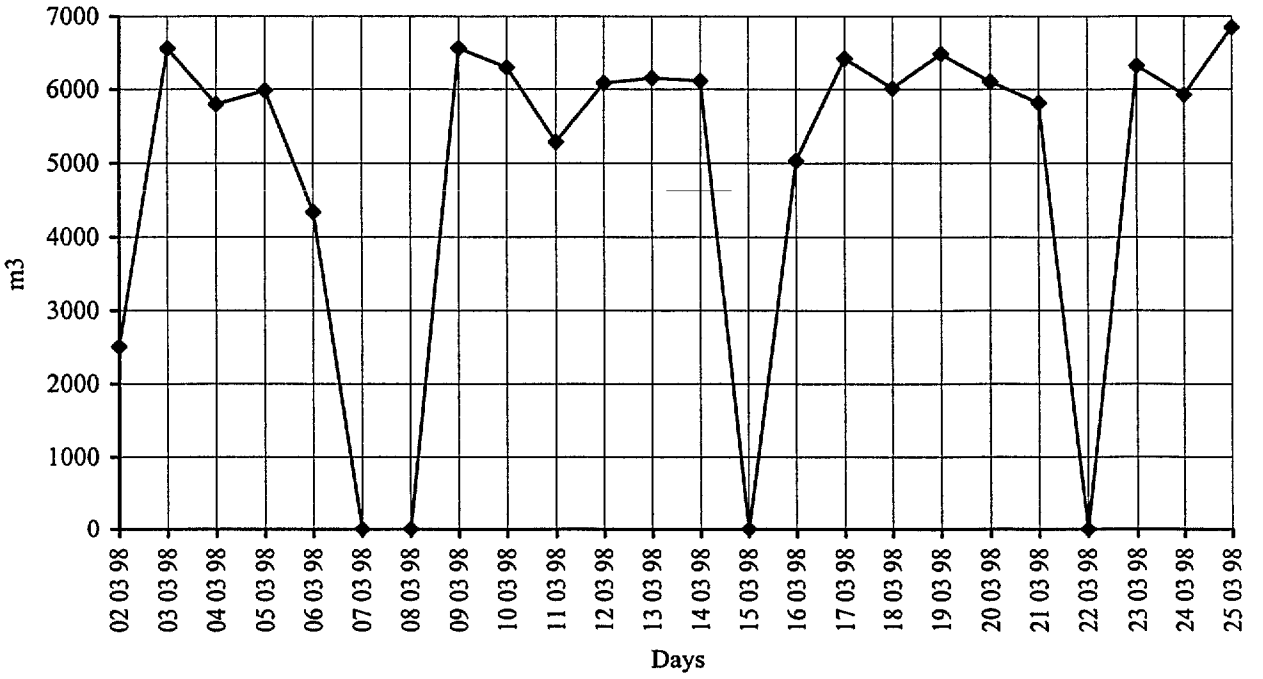

Fig 18

22

Specific consumption of gas per 1 tonne of sugar products

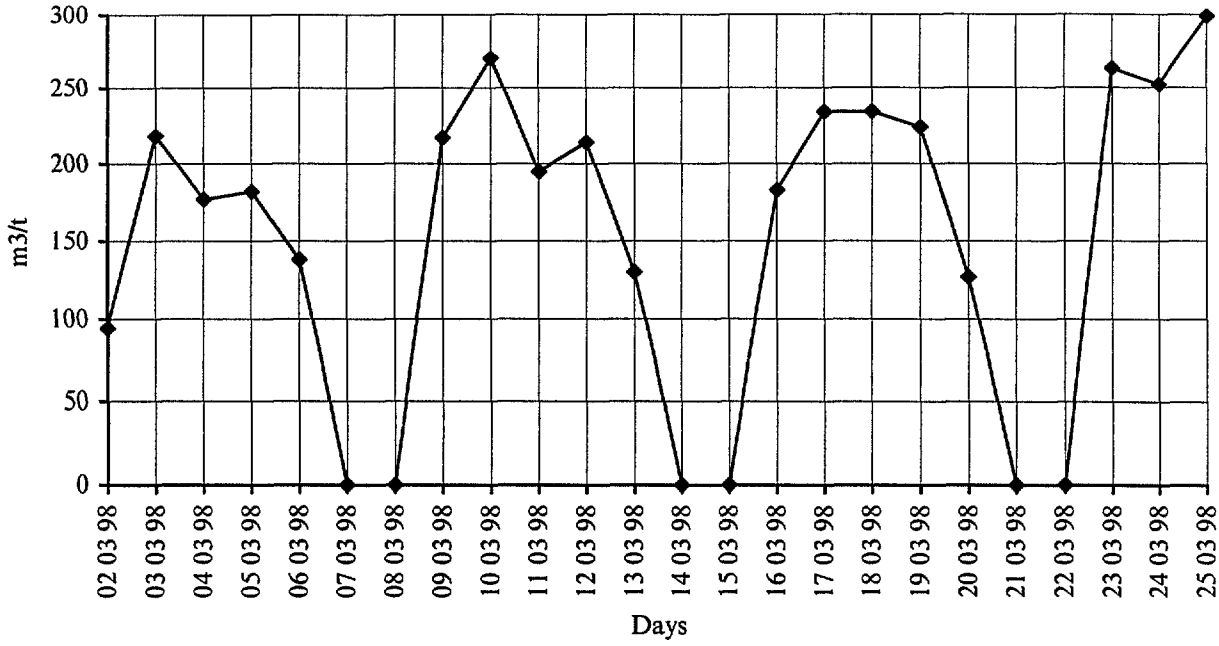

Fig 19

Specific gas consumption per 1 tonne of sugar confectionery versus the production rate per day

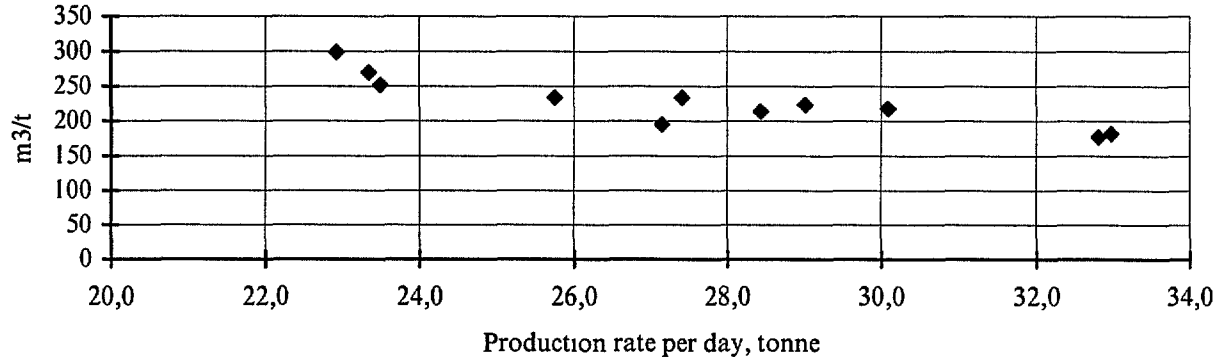

Fig 20

Efficiency of gas utilization (thermal energy) rises with rising the production rate and at the productivity of 28 to 30 tonnes of sugar products per day it is 200 to 220 m^3 per 1 tonne of the products

Table 11

Day	Production output of flour confectionery, tonne	Natural gas consumption by the waffle furnaces, m³	Specific gas consumption per 1 tonne of flour confectionery, m³/tonne
2 03	0	225	0
3 03	2 4	552	230
4 03	2 86	489	171
5 03	3 11	947	305
6 03	2 66	431	162
7 03	0	0	0
8 03	0	0	0
9 03	2 35	482	205
10 03	1 78	437	246
11 03	2 59	718	277
12 03	0 88	197	224
13 03	0 45	423	940
14 03	0	0	0
15 03	0	0	0
16 03	2 31	207	90
17 03	2 89	406	141
18 03	2 64	375	142
19 03	2 6	422	162
20 03	2 26	446	197
21 03	0	0	0
22 03	0	0	0
23 03	1 77	385	218
24 03	2 04	632	310
25 03	2 51	191	76
Total	**38 1**	**7 965**	**209 1**

Production of flour confectionery

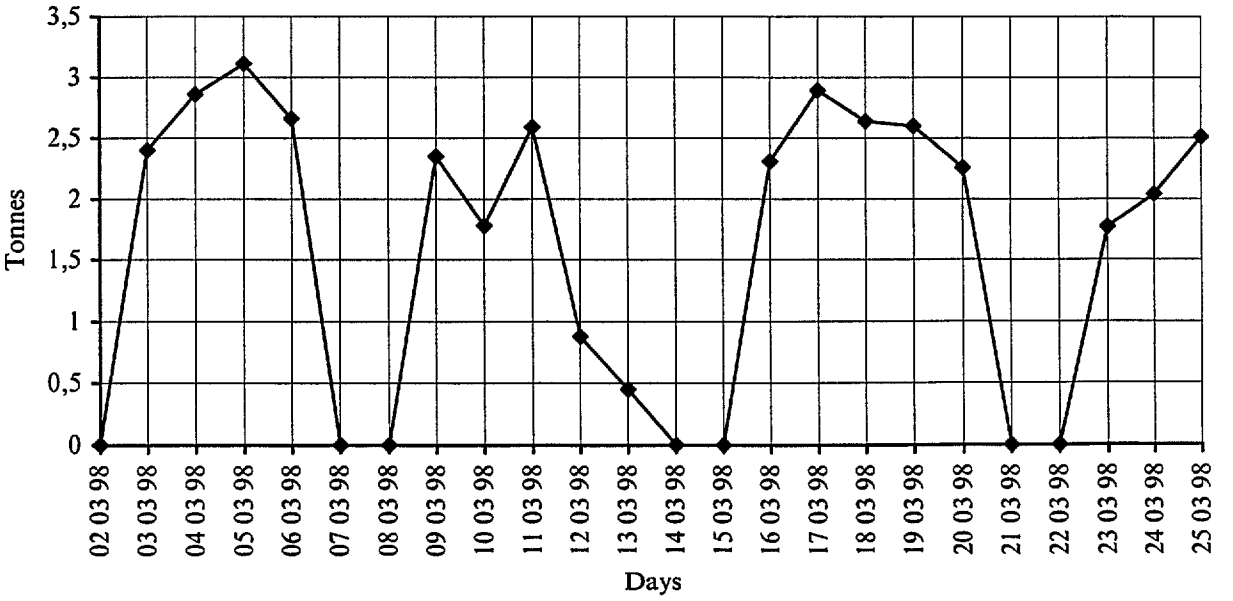

Fig 21

24

Natual gas consumption by the waffle furnaces

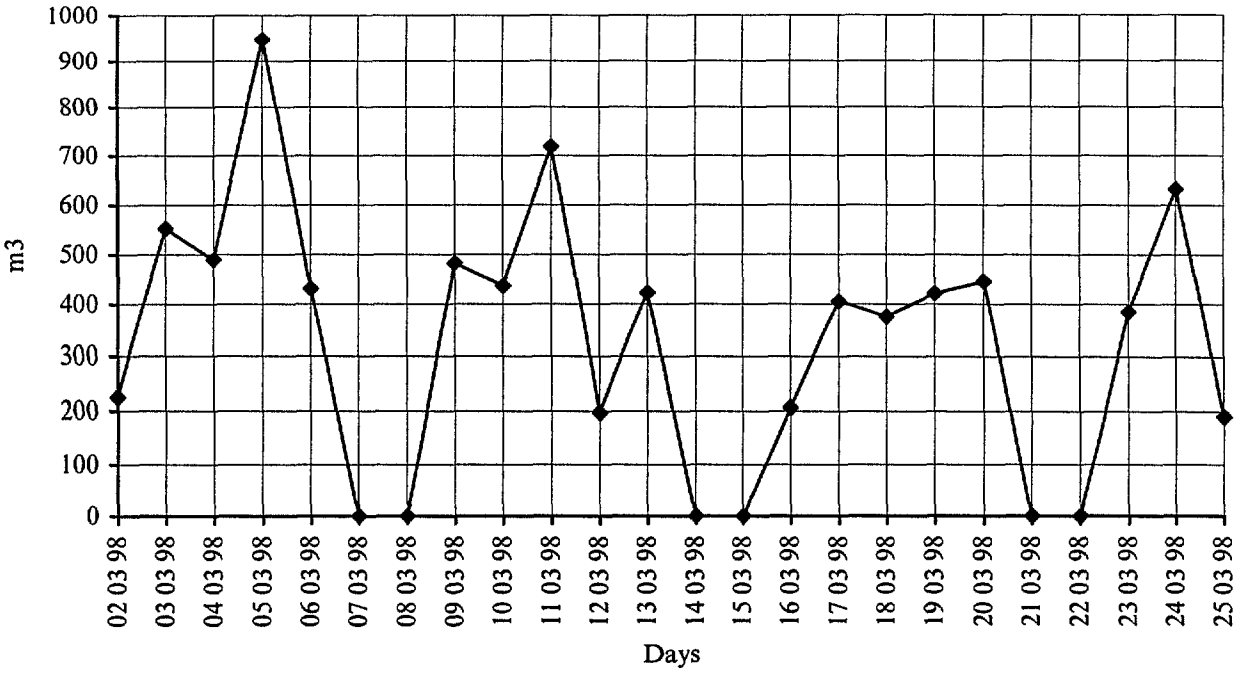

Fig 22

Specific consumption of gas per 1 tonne of flour confectionery

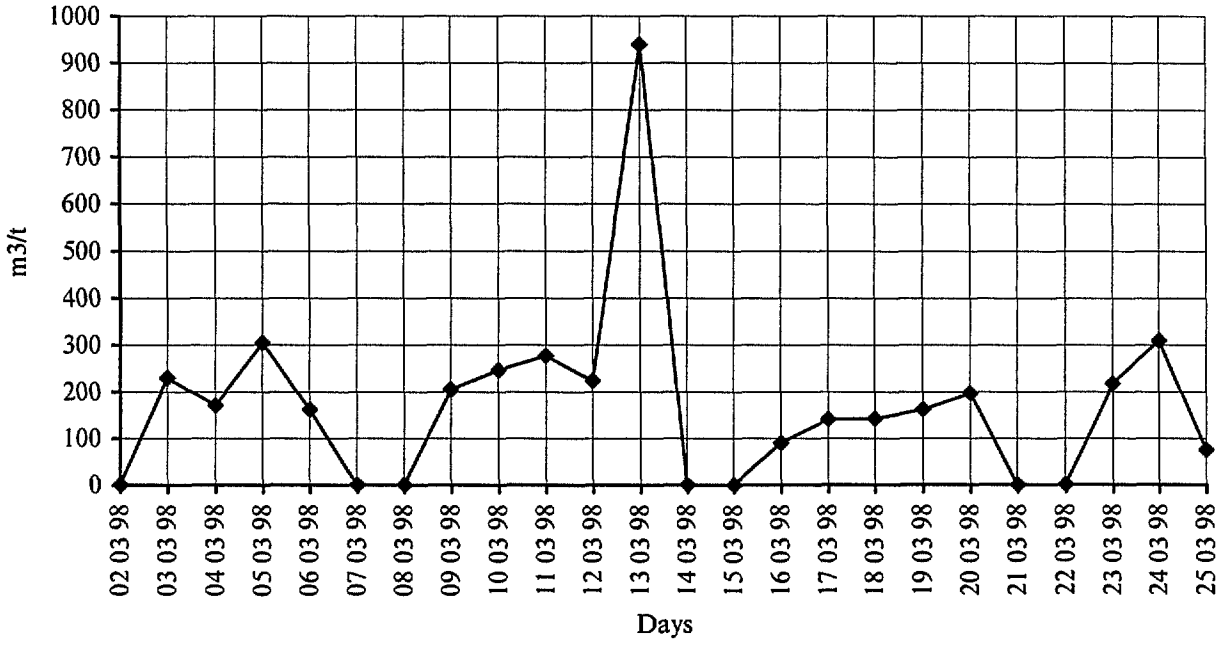

Fig 23

25

Specific gas consumption per 1 tonne of flour products versus the production level per day

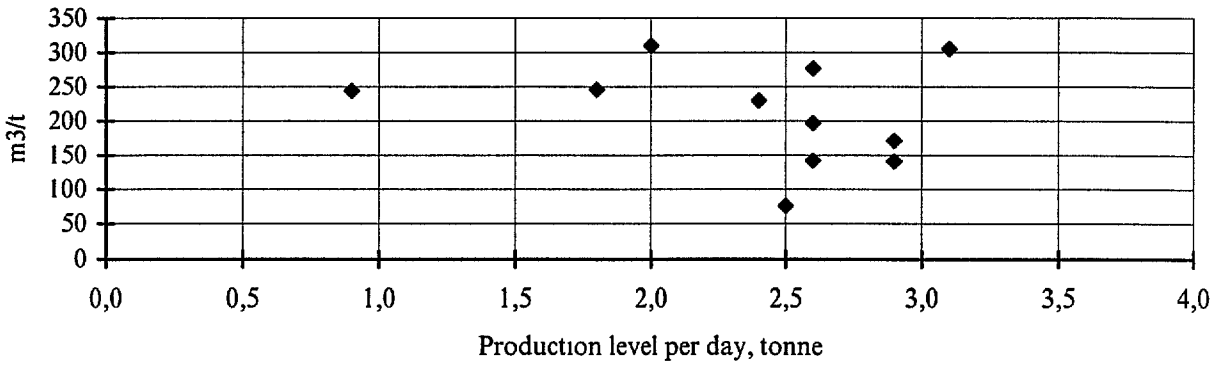

Fig 24

The specific consumption of natural gas per 1 tonne of flour confectionery in a wide range from 76 m^3/t to 310 m^3/t has a chaotic character A probable reason for that may be incorrect data about the amount of the produced products

In case of introduction of a system for controlling and planning the natural gas consumption per unit of the products, there should be matched in time the daily data in regard of gas consumption and of the furnace productivity

7 0 PREVIOUS ENERGY INITIATIVES

At the factory every year energy conservation plans are developed In 1996 - 1997 the following measures were implemented

1 A system for automatical controlling the steam boilers of *DKVR*-types was commissioned (the level in the drum, the low pressure in the furnace, the steam pressure, the Fuel-to-air ration)
2 A steam trap was installed in the steam collector
3 A regular repair was performed for the steam supply pipelines and hot water supply pipelines
4 Water economizers were fixed in the steam boilers

In 1998-1999 there is planned the following

1 Installation of a dearator in the boiler-house
2 Replacement of the gas meter in the boiler-house with an automatic system with the error class of ± 1 %
3 Modernization of the steam trap assemblies of the processing equipment

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8 0 ENERGY CONSERVATION OPPORTUNITIES

Establishment of energy management system (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 *Khmelnytskyi Confectionery*, 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 *Khmelnytskyi Confectionery*, 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

It is proposed 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 — 113,000 kW h
- natural gas — 130,000 m^3
- drinking water — 13,000 m^3

Project costs — US $27,892
Payback period— 1 5 years

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Automatization of the system for metering natural gas consumption (ECO #2)

Metering of gas consumption is performed by means of *RG-640* rotational meter of 2 0 Precision Class The gas consumption is calculated on the basis of daily readings and that is entered into the register

The current metering system does not allow to evaluate operatively the consumption and efficiency of gas utilization, nor develop a standard rate base and introduce a system for controlling and planning energy costs

It is proposed to install at the confectionery an automatized system for gas consumption metering, with the measurement error of ± 1 % that would make it possible to implement the effects gained from implementation of the energy conservation measures and to make mutual settlements with the gas supplying organization on the basis of the objective data

Expected saving

- natural gas — 116,300 m^3

The project costs — US $15,000
Payback period — 1 6 years

Temperature controlling valves (ECO #3)

In the energy balance of the factory about 8 to 10% of thermal energy is used for heating water to the temperature of 65 to 75°C that is used for the processing and domestic and communal needs Water heating is done in steam-and-water tube heaters of the capacitive type

There are no automatic temperature controls on the heaters The water temperature at the heaters outlet is practically not provided if the load changes

It is proposed to install on each heater a system for automatical temperature control including a control valve of "direct acting" and a strainer

Expected saving

- natural gas — 14,300 m^3
  Projects costs — US $1,800
  Payback period — 1 5 years

Steam traps (ECO #4)

The steam-and-water heaters in the hot water supply system are not equipped with steam traps, which significantly worsen the efficiency of their work, causes steam flash and losses of heat in case of the secondary boiling of the condensate

It is proposed to install on each heater a float steam trap As it is know from practice, this measure will improve the operation efficiency not less than 15 per cent

Expected saving

- natural gas — 21,400 m^3
  Project costs — US $1,400
  Payback period — 0 8 year

Transfer of the enterprise heating system form steam on hot water (ECO #5)

The registers of the heating system are equipped with steam trap assemblies, which worsen their operation efficiency, causes steam flash and its further loss in case of the secondary boiling of the condensate

The current steam heat supply system requires high reliability and it must be protected from the pressure rising above 3 barg, while the pressure of the steam for the processing needs must be not lower than 4 to 5 barg In fact, steam is taken from the collector of the common steam for the processing needs, the pressure is decreased for the heating needs manually regularly by means of dampers Automatic reduction plants on the steam heat supply pipelines are absent, the protection valves on the steam of old design are not reliable in operation The factory should perform technical measures aimed at improvement of the reliability of operation of the steam heat supply system in accordance with the requirements of the safety engineering and labor protection code

It is proposed to perform modernization of the steam heat supply system at the factory with transferring it on hot water with the temperature of the heat agent of up to 95°C

The scope of the reconstruction works should include the following

- examination of the conditions of the current system, making sure of the thermal loads, making checking calculations, development of the project,
- installation in the current premises of up-to-date automatized independent thermal stations with thermal heat exchangers, circulation pumps, an automatical temperature control system

Expected saving

- natural gas — 73,000 m^3
  Project costs — US $13,500
  Payback period— 1 1 years

Utilization of the heat after continuous blowing of the steam boilers (ECO #6)

To decrease the salt content in the boiler water that would provide the required steam quality, the boilers are continuously blown from the boiler balance The standard value of the portion of the continuous blowing for the operated type of boilers is 5 to 10 per cent The boiler water after expanding with the temperature of 110°C is supplied then into the blowing well where it is cooled to the cold water with the temperature of 50°C and after that it is discharged into the sewage system

It is proposed to mount a plate-type heat exchanger cooling the blown water to the temperature of 20 to 30°C by heating the chemically purified water coming into the feeding tank (deaerator) in the boiler-house This will make it possible to decrease the losses of heat on the needs directly in the boiler-house and to decrease the costs of water and waster water

Expected saving

- natural gas — 11,400 m^3
  Project costs — US $1,700
  Payback period — 0 9 year

Utilization of the heat from the exhaust gases from *DKVR-4/13* Boiler (ECO #7)

Steam supply to the factory is provided from its independent boiler-house with two steam boilers of *DKVR-4/13*-type working on natural gas The steam production capacity of the boilers is 4 tonnes of steam per hour, the steam pressure is 13 barg

The actual average steam production capacity per year is about 2 6 to 2 8 t/h at the steam pressure of 8 barg As there is no deaeration plant, the average temperature of the feed water supplied into the well is sustained at the level of 50^{0}C

As in the boiler-house a dearation plant is to be installed, the temperature of the feed water at the inlet into the boiler will be equal to 100 to 102^{0}C This will cause rising of the temperature of the exhaust gases approximately by 15 per cent, or the boiler efficiency will be decreased by 0 9 to 1 per cent The dearator plant of the atmospheric type will improve in addition the losses of heat for the needs in the boiler-house directly approximately by 0 4 to 0 5 per cent

It is proposed to mount after the water economizer a compact heat exchanger-recovery boiler to heat the air used for burning by using the heat from the leaving exhaust gases Application of the recovery-boiler will make it possible to improve the boiler efficiency by 3 5 to 4 5 per cent With that there are practically not to be changed the oversize of the boiler-house, there remains the same feeding draught-and-blow equipment, and the amount of the emissions of harmful substances goes down

Expected saving

- natural gas — 62,000 m^3
- water — 2,000 m^3
  Project costs — US $5,450
  Payback period — 1 1 years

Modernization of the steam-and-water condensate system (ECO #8)

Steam is used for the processing needs, for hot water supply and for heating The condensate is returned back into the boiler-house from the condensate back-pumping station that is placed in the main production building Condensate from the sort-purposed candies production workshop and from the retail-purposed candies production workshop is returned back directly into the condensate collection tank that is placed in the boiler-house

As the steam and condensate supply system at the factory has been operated for a long time , it is not operated now efficiently and it needs either repair or modernization

It is proposed to perform modernization of the steam and condensate supply system of the factory on the basis of up-to-date equipment that would make it possible to increase the efficiency and reliability of its operation

Expected saving

- natural gas — 201,500 m^3
- water — 4,800 m^3
  Project costs — US $42,550
  Payback period — 2 years

9 0 ENVIRONMENTAL IMPACTS OF THE RECOMMENDATIONS

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 - 629,900 m^3
  - electric power - 133,000 kW h
- Decrease of harmful emissions into the atmosphere

CO - 629,900 m^3 0 28 kg/10^3 m^3 + 133,000 kW h 0 5 kg/10^3 kW h = 243 kg
NO_x -629,900 m^3 1,215 kg/10^3 m^3 + 133,000 kW h 2 2 kg/10^3 kW h = 1,058 kg
SO_2 - 133,000 kW h 9 9 kg/10^3 kW h = 1,317 kg
Ash - 133,000 kW h 4 4 kg/10^3 kW h = 585 kg

The total decrease of harmful emissions - 3 2 tonnes per year

APPENDIX A ENERGY CONSERVATION OPPORTUNITIES (ECOs)

Energy conservation opportunities (ECOs)

ECO #1	Introduction of an energy management program
ECO #2	Automatization of metering the natural gas consumption
ECO #3	Temperature controlling valves
ECO #4	Steam traps
ECO #5	Transfer of the enterprise heat supply system from steam on hot water
ECO #6	Utilization of heat after continuos blowing of the steam boilers
ECO #7	Utilization of heat from the exhaust gases from *DKVR-4/13* Boiler
ECO #8	Modernization of the steam-and-condensate system

Energy conservation opportunities

ECO - 1 Establishment of energy management system

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

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 combustion analyzer
- 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

If there are a set of 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 (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

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 enterprise

Calculation of the 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 from 5 to 10 per cent

The energy saving will be as follows

1	Electric power	1,510,000 kW h • 0 075 = 113,300 kW h
2	Natural gas	1,739,000 • 0 075 = 130,000 m^3
3	Water	173,600 m^3 • 0 05 = 13,000 m^3

Calculation of a yearly saving of costs

1 If 1,000 kW h cos US $43, the saving of the electric power cost will be
113,300 kW h • US $43 = US $4,872
2 If 1,000 m^3 of gas cost US $83, the saving of gas costs will be
130,000 m^3 • US $83 = US $10,790
3 If 1,000 m^3 of water cost US $240, the saving of water costs will be
13,000 m^3 • US $240 = US $3,120
The total saving of the energy costs will be
US $4,872 + US $10,790 + US $3,120 = US $18,782

Commissioning costs

Approximate cost of a set of the measuring instruments is US $24,000
The costs of implementation of an energy management system, as it is shown by practice, are about 20 per cent of the expected saving, or US $19,458 • 0 2 = US $3,892
The total costs are US $24,000 + US $3,892 = US $27,892

The simple payback period is US $27,892 US $18,782 ≈ 1,5 years ≈ 18 months

ECO - 2 Automatization of the system for metering the natural gas consumption

Description of the opportunity

The enterprises consumes during a year 1 7 million m^3 of natural gas that cost about US $144,000, 1 55 million m^3 out of that that is used at the boiler-house, that costs approximately US $129,000 Metering of gas consumption is done by means of *RG-640* rotational- type meter of 2 0 precision class Gas consumption is calculated on the basis of the daily data and they are entered into the register

The current metering system does not allow to evaluate operatively the consumption and efficiency of gas utilization, nor develop a standard rate base and introduce a system for controlling and planning energy costs

It is proposed to install at the confectionery an automatized system for gas consumption metering, with the measurement error of ± 1 % that would make it possible to implement the effects gained from implementation of the energy conservation measures and to make mutual settlements with the gas supplying organization on the basis of the objective data

At any time complete information is available concerning the gas consumption, which makes it possible to make urgent decisions in regard of controlling the operation mode of the equipment, the issue of saving the consumption including The expected saving of the gas consumption is 5 to 10 per cent

Calculation of the yearly energy saving

1 Yearly saving of natural gas for the boiler-house — 1,550,000 m^3
2 Expected saving of the costs (set) — 7 5 %
3 Expected saving of natural gas
1,550,000 m^3 • 0 075 = 116,300 m^3

Calculation of saving the costs

1 1,000 m^3 of gas cost — US $83
2 Yearly saving of the costs 116,300 m^3 • US $83 = US $9,653

Commissioning costs

The automatical metering system "***Flowtech***" that is included into the State Register of Ukraine or an equivalent to be installed on the "turn-key" basis is US $15,000

Simple payback period US $15,000 US $9,653 = 1 6 years ≅ 19 months

ECO - 3 Temperature controlling valves

Description of the opportunity

In the energy balance of the enterprise about 8 to 10 per cent of the thermal energy is used for heating water to the temperature of 65 to 75°C that is then used for the processing needs as well as for the domestic purposes Heating of water is done in steam-and-water heaters of the capacitive type

There are no automatic temperature controls on the heaters There is practically no provision of changing the temperature of the water at the inlet into the heaters, if the load varies

During the measurements fulfilled while performing the audit, the temperature of the water after Heater #1 was 95°C, that after Heater #2 was 85°C

It is proposed to install on each heater a system for automatic controlling the temperature, the system should include a controlling valve of the "direct acting" and a strainer The expected effect will be decreasing the steam consumption by not less than 10 per cent

Calculation of the yearly energy saving

1 The amount of the generated thermal energy per year — 11,407 Gcal (calculated value)
2 The portion of the thermal energy for hot water supply (according to the balance) — 9%
3 Consumption of thermal energy for hot water supply
11,407 Gcal • 0 9 = 1,027 Gcal

1 Expected decreasing of the steam consumption (set) — 10 %
2 Decreasing the thermal energy consumption
1,027 Gcal • 0 1 = 103 Gcal

1 Specific gas consumption per 1 Gcal of the generated heat (calculated value) — 135 m^3
2 Consumption directly for the needs of the boiler-house — 3 %
3 Specific gas consumption per 1 Gcal of the provided heat
135 m^3 • 1 03 = 139 m^3

Expected yearly gas saving
103 Gcal • 139 m^3/Gcal = 14,317 m^3

Calculation of the yearly saving of the costs

1 1,000 m^3 of gas cost — US $83
2 Yearly saving of the costs
14,300 m^3 • US $83 = US $1,187

Commissioning costs

1 The cost of a direct-effect controlling valve, of steel, flanged, normally opened DN32 in the set with a sensor-actuator and a strainer is US $800
2 Installation costs (set) — US $100
3 Total costs of two heaters (US $800 + US $100) • 2 = US $1,800

Simple payback period US $1,800 US $1,187 = 1 5 years ≅ 18 months

ECO - 4 Steam traps

Description of the opportunity

Steam-and- water heaters in the hot water supply system are not equipped with steam traps, which significantly worsen the efficiency of their operation, causes steam flash and losses of heat in case of the secondary boiling of the condensate
During the measurements while performing the audit, the temperatures of the steam and of the condensate were the same and they were respectively equal to 154 to 150^{0}C afor Heater #1 and 135 to 130^{0}C for Heater #2, which proves presence of steam flash

It is proposed to install on each heater a float steam trap As it is known from the world practice, implementation of this measure will improve the efficiency of operation of the heaters by not less than 15 per cent

Calculation of the energy saving

1 Thermal power consumption for the heaters per year (ECO #3) — 1,027 Gcal
2 Expected decreasing of the steam consumption (set) — 15 %
3 Decrease in consumption of the thermal energy
1,027 Gcal • 0 15 = 154 Gcal
4 Specific gas consumption per 1 GCal of the provided heat (ECO #3) — 139 m^3
5 Expected gas saving
154 Gcal • 139 m^3/Gcal = 21,406 m^3

Calculation of the yearly saving of the costs

1 1,000 m^3 of gas cost — US $83
2 Saving of the costs per year 21,400 m^3 • US $83 = US $1,776

Commissioning costs

1 The cost of an inverted bucket trap, of steel, flanged, of DN25 type with a built-in strainer — US $600
2 Installation works (set) — US $100
3 Total costs on 2 heaters (US $600 + US $100) • 2 = US $1,400

Simple payback period US $1,400 US $1,776 = 0 8 year ≅ 10 months

ECO - 5 Transfer of the enterprise heating system from steam on hot water

Description of the opportunity

The enterprise has a heat supply system using 18 to 20 per cent of the generated thermal energy per year The registers of the heating system are equipped with steam trap assemblies, which worsen their operation efficiency, causes steam flash and its further loss in case of the secondary boiling of the condensate

The current steam heat supply system requires high reliability and it must be protected from the pressure rising above 3 barg, while the pressure of the steam for the processing needs must be not lower than 4 to 5 barg In fact, steam is taken from the collector of the common steam for the processing needs, the pressure is decreased for the heating needs manually regularly by means of dampers Automatic reduction plants on the steam heat supply pipelines are absent, the protection valves on the steam of old design are not reliable in operation The factory should perform technical measures aimed at improvement of the reliability of operation of the steam heat supply system in accordance with the requirements of the safety engineering and labor protection code

It is proposed to perform modernization of the steam heat supply system at the factory with transferring it on hot water with the temperature of the heat agent of up to 95°C

The scope of the reconstruction works should include the following

- examination of the conditions of the current system, making sure of the thermal loads, making checking calculations, development of the project,
- installation in the current premises of up-to-date automatized independent thermal stations with thermal heat exchangers, circulation pumps, an automatical temperature control system The thermal capacity of the independent thermal stations is approximately 0 2 to 0 35 Gcal

Calculation of the yearly energy saving

1 Yearly consumption of natural gas for the boiler-house — 1,550,000 m^3
2 The portion of the gas consumption used to cover the thermal load in respect of heating — 19 %
3 Consumption of gas for heating purposes 1,550,000 m^3 • 0 19 = 294,500 m^3
4 Expected decrease in the natural gas consumption — 25 %
5 Saving of natural gas 294,500 m^3 • 0 25 = 73,600 m^3

Calculation of the yearly saving of the costs

1 1,000 m^3 of gas costs — US $83
2 Saving of the costs resulting from decreasing the gas consumption (set)
73,600 m^3 • US $83 = US $6,109
3 Saving of the costs aiming at improvement the reliability of the current steam system (set) — US $6,000
4 The total saving of the costs US $6,109 + US $6,000 = US $12,109

Commissioning costs

Implementation of the project on the "turn-key" basis (study, designing, installation, adjustment) — US $13,500

Simple payback period US $13,500 US $12,109 = 1 1 years ≅ 13 months

ECO - 6 Utilization of the heat after the continuous blowing of the steam boilers

Description of the opportunity

To decrease the salt content in the boiler water that would provide the required steam quality, the boilers are continuously blown from the boiler balance The standard value of the portion of the continuous blowing for the operated type of boilers is 5 to 10 per cent The boiler water after expanding with the temperature of 110°C is supplied then into the blowing well where it is cooled to the cold water with the temperature of 50°C and after that it is discharged into the sewage system

It is proposed to mount a plate-type heat exchanger cooling the blown water to the temperature of 20 to 30°C by heating the chemically purified water coming into the feeding tank (deaerator) in the boiler-house This will make it possible to decrease the losses of heat on the needs directly in the boiler-house and to decrease the costs of water and waste water

Calculation of the natural gas consumption

1 Steam pressure in the boiler drum — 8 barg
2 Thermal content of the steam — 662 5 kcal/kg
3 Thermal content of the steam water — 177 kcal/kg
4 Yearly production output of the thermal energy by the boiler-house (calculation) — 11,407 Gcal
5 Steam production per year $11,407 \cdot 10^6$ 662 5 = $17\ 2 \cdot 10^6$ kg
6 Percentage of the continuous blowing (set) — 7%
7 The amount of the blowing water per year $17\ 2 \cdot 10^6$ kg • 0 07 = $1\ 2 \cdot 10^6$ kg
8 Percentage of the blowing water with the temperature of 110°C that is discharged into the canalization system after the flash vessel (p = 0 5 barg) — 85%
9 Amount of the blowing water discharged into the canalization system
$1\ 2 \cdot 10^6$ kg • 0 85 = $1\ 02 \cdot 10^6$ kg

10 Thermal content of the discharged water — 110 kcal/kg
11 Amount of heat lost with the blowing water
$1\ 2 \cdot 10^6$ kg • 110 kcal/kg = 112 2 Gcal

12 Decrease in the losses of heat after installation of a heat exchanger — 75%
13 Heat saving 112 2 Gcal • 0 75 = 84 2 Gcal
14 Specific gas consumption per 1 Gcal of the generated heat (calculated value) — 135 m^3
15 Expected gas saving per year 84 2 Gcal • 135 m^3 = 11,367 m^3

Calculation of the yearly saving of water

1 The amount of the water for the continuous blowing that is discharged into the canalization system with the temperature of 110°C $112\ 2 \cdot 10^6$ kcal 110 kcal/kg = 1,020 t (m^3)
2 The amount of water, with the temperature of 20°C that is required for lowering the temperature of the blowing water to 50°C(according to the heat balance) — 2,020 m^3
3 Saving of water — 2,020 m^3
4 Saving of waste water — 2,020 m^3

Calculation of the yearly saving of the costs

1 1,000 m^3 of gas cost — US $83
2 Saving of the gas costs 11,400 m^3 • US $83 = US $946
3 1 m^3 of water (the tariff) — US $0 24
4 Saving of the water costs 2,020 m^3 • US $0 24 = US $586
5 1 m^3 of waste water (the tariff) — US $0 2

6 Saving of the waste water costs 2,020 m^3 • US $0 2 = US $404
7 Total saving of energy costs US $946 + US $586 + US $404 = US $1,936

Commissioning costs

1 The cost of a heat exchanger of "water-water" type with the thermal load of 200 kW (0 17 Gcal) — US $1,300
2 The cost of an ancillary blocking fixture and the costs of the installation works (set) — US $400
3 Total costs US $1,300 + US $400 = US $1,700

Simple payback period US $1,700 US $1,936 = 0 9 year ≅ 11 months

ECO - 7 Utilization of the heat from the exhaust gases from the *DKVR-4/13* Boiler

Description of the opportunity

Steam supply id provided at the confectionery from its own boiler-house with two steam boilers of *DKVR-4/13*-type working on natural gas The steam production capacity of the boilers is 4 tonnes of steam per hour, the steam pressure is 13 barg

The actual average steam production capacity per year is about 2 6 to 2 8 t/h at the steam pressure of 8 barg As there is no deaeration plant, the average temperature of the feed water supplied into the well is sustained at the level of 50°C

When the audit was being performed, at the load of 2 8 t/h Boiler #2 had the following characteristics

- steam pressure in the drum — 8 0 barg,
- the temperature of the exhaust gases before the economizer — 306°C,
- the temperature of the exhaust gases after the economizer — 144°C,
- excess air before the economizer — 45%,
- excess air after the economizer — 49%,
- NO_x-content after the economizer — 231 ppm,
- CO-content after the economizer — 2 ppm

The measurements were made by means of *"BACHARACH"* gas analyzer As at the boiler-house a dearating plant is top be installed, the temperature of the feed water at the inlet into the boiler will be equal to 100 to 102°C This will cause the temperature of the exhaust gases approximately by 15°C, or in other words, it will decrease the boiler efficiency by 0 9 to 1 per cent The deaerator plant of the atmospheric type will increase the heat losses still more, which is accounted by the own needs in the boiler-house directly, approximately by 0 4 to 0 5 per cent

It is proposed to mount after the water economizer a compact heat exchanger-recovery boiler to heat the air used for burning by using the heat from the leaving exhaust gases Application of the recovery-boiler will make it possible to improve the boiler efficiency by 3 5 to 4 5 per cent With that there are practically not to be changed the oversize of the boiler-house, there remains the same feeding draught-and-blow equipment, and the amount of the emissions of harmful substances goes down

The oversize of the recovery-boiler

800 x 800 x 800

Calculation of energy saving

1 Yearly consumption of natural gas in the boiler-house — 1,550,000 m^3
2 Expected decrease in gas consumption — 4 0%
3 Saving of natural gas per year 1,550,000 m^3 • 0 04 = 62 000 m^3

Calculation of the yearly saving of the costs

1 1,000 m^3 of gas cost — US $83
2 Saving of gas costs 62,000 m^3 • US $83 = US $5,146

Commissioning costs

1 The costs of the recovery boiler designing works, of the contract supervision and of the adjustment — US $4,950
2 Installation costs — US $500
3 Total costs US $4,950 + US $500 = US $5,450

Simple payback period US $5,450 US $5,146 = 1 1 years ≅ 13 months

ECO - 8 Modernization of the steam-and-condensate system

Description of the opportunity

The enterprise has its own boiler-house that in 1997 provided production of about 11,400 Gcal of thermal energy in form of saturated steam with the pressure of 8 to 8 5 barg

Steam is used for the processing needs, for hot water supply and for heating The condensate is returned back into the boiler-house from the condensate back-pumping station that is placed in the main production building Condensate from the sort-purposed candies production workshop and from the retail-purposed candies production workshop is returned back directly into the condensate collection tank that is placed in the boiler-house

As the steam and condensate supply system at the factory has been operated for a long time , it is not operated now efficiently and it needs either repairing or to be modernized

1 For the majority of the equipment steam traps are not operateable Due to the steam flash the thermal efficiency of the equipment decreases, which leads to overconsumption of steam by 10 to 15 per cent
2 There has got out of fit the jacket-and-tubular heat exchanger used for cooling and recovery of the condensate heat The overheated condensate at the temperature of 125 to 130°C comes into the condensate tank where its secondary boiling takes place, the pressure in the tank rises and the steam ejects into the atmosphere The approximate losses of heat are 4 to 5 per cent
3 There are absent or they are not operateable the steam traps used for removal of condensate from the distributing steam collectors and line-end sections of steam pipelines in the production buildings
   There are no automatic air valves in the steam distributing system at the enterprise

   In conditions of everyday stating and stopping the production facilities the presence of condensate and air in the steam system significantly worsen the quality of the steam and the efficiency of its utilization Approximately the heat losses are 1 5 to 2 0 per cent
4 Operation of a separate piece of the steam equipment is accompanied by a forced direct discharge of the condensate with the temperature of 90 to 110°C into the canalization system The main cause is an insufficient condensate pressure to overwhelm the pressure in the common condensate line
5 The equipment used in parallel the check-valves are absent or they are not fit, which worsens the conditions for starting a plant from the cold state and it causes additional losses of steam and condensate
6 In the thermal station of the main production building the automatic controller of the pressure 6/4 barg is not operateable Pressure control is performed regularly manually, which does not provide the required parameters of the steam and its efficient utilization
7 According to estimates, losses of condensate are 55 to 60 per cent, which increases the fuel consumption in the boiler-house by 5 to 6 per cent
8 The steam supply and condensate return system in the future can become a factor braking development of the basic production facilities of the factory

It is proposed to perform modernization of the steam and condensate supply system of the factory on the basis of up-to-date equipment that would make it possible to increase the efficiency and reliability of its operation

- to improve the efficiency of the processing equipment using steam, by installing new up--to-date steam traps,
- to decrease heat losses with the secondary boiling steam by installing an expansion tank and using the secondary steam for water heating,
- to recover the condensate heat by installing plate-type heat exchangers,

- to improve the quality of steam by installing in the steam distribution system steam traps and automatic air discharges,
- to provide optimal conditions for operating the boilers during everyday starts from the cold state, by installing automatic air discharges and vacuum breakers,
- to provide stable work of the parallely operated equipment by installing disk check valves,
- to provide sustaining the required steam pressure by installing an automatic valve of the "direct acting",
- to repair steam and condensate leaks by replacing the fixture with highly tight and reliable one

Implementation of this proposal will make it possible to improve the efficiency of the thermal energy utilization approximately by 20 per cent At the same time the reliability of functioning of the condensate collection and return system will get better

Calculation of the expected energy saving

1 Yearly consumption of natural gas for the boiler-house — 1,550,000 m^3
2 Percentage of the consumption of thermal energy for the processing needs (according to the balance) — 65%
3 Expected improvement of the efficiency of the steam and condensate system providing implementation of the set of measures (set on the ground of an estimation) — 20%
4 Saving of gas per year 1,550,000 $m^3 \cdot 0\ 65 \cdot 0\ 2 = 201{,}500\ m^3$

Calculation of the expected saving of the chemically treated water

1 Yearly production of steam (ECO #6) — $17\ 2 \cdot 10^6$ kg
2 Expected decrease in steam consumption per year
$17\ 2 \cdot 10^6\ kg \cdot 0\ 2 = 3.44 \cdot 10^6\ kg$
3 Saving of the chemically treated water per year — 3 440 m^3
4 Saving of water for regeneration and washing filters (set as 20 per cent of the consumption of the chemically treated water) 3,440 $m^3 \cdot 0\ 2 = 688\ m^3$
5 Saving of contaminated waste water — 688 m^3
6 Total saving of water per year 3,440 m^3 + 688 m^3 + 688 m^3 = 4,816 m^3

Calculation of the expected saving of the costs

1 1,000 m^3 of gas cost — US $83
2 Saving of the gas costs 201,500 m^3 • US $83 = US $16,725
3 1 m^3 of chemically treated water costs US $0 075
4 Saving of costs of the chemically treated water 3,440 m^3 • US $0 75 = US $2,580
5 Total saving of the costs US $16,725 + US $2,580 = US $19,305

Regular repair

The costs of the regular repair of the current equipment per year (set) — US $2,000
Total saving of the costs US $19,305 + US $2,000 = US $21,305

Commissioning costs

1 The cost of inverted bucket steam traps and of thermodynamic traps, flanged, with built-in strainers, of *DN15 20, 25* and *PN16* types (30 to 35 units) — US $8 000
2 The cost of disk check valves mounted between the flanges, of *DN15, 20* and *25* and *PN16* types — US $1,000
3 The cost of ball valves, flanged, of *DN15, 20* and *25* and *PN16* types (20 to 25 units) — US $3,000
4 The cost of the air valves, threaded, $^1/_2$" (20 units) — US $1,200
5 The cost of the vacuum breakers, threaded, $^1/_2$" (20 units) — US $1,200
6 The cost of the flash vessel in a set with a safety valve and a steam trap assembly (1 unit) — US $2 000
7 The cost of the pressure reducing valves of direct acting *DN80* and *PN16* types, flanged, in a set with a strainer (1 unit) — US $2,500
8 The cost of the plate-type heat exchangers (2 units) — US $2,800
9 The total cost of the basic equipment — US $21,700
10 The total cost with taking into account the VAT, transportation costs and customs fees and duties (set as 50 per cent)
US $21,700 • 1 5 = US $32,550

1 The cost of the designing, installation and adjustment works as well as that of the ancillary equipment (set) — US $10,000
2 The total costs US $32,550 + US $10,000 = US $42,550

Simple payback period US $42,550 US $21,305 = 2 years ≅ 24 months

Note The cost of the recommended equipment was set approximately When aiming at development of a certain project of modernization, choosing equipment and the supplier, making a specification for ordering, works concerning making the steam and condensate balance should be done

APPENDIX B AUDIT RECORDS AND ENTERPRISE DATA

"Photographs" of the operation schedule of *DKVR-4/13* Boilers on April 15, 1998

***DKVR-4/13* Boiler #2 (after the economizer)**	***DKVR-4/13* Boiler #2 (after the economizer)**	***DKVR-4/13* Boiler #2 (before the economizer)**	***DKVR-4/13* Boiler #2 (before the economizer)**
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 YCO 513	SER NO YCO 513	SER NO YCO 513	SER NO YCO 513
TIME 08 52	TIME 08 55	TIME 09 09	TIME 09 12
DATE 15, 04, 98	DATE 15, 04, 98	DATE 15, 04, 98	DATE 15, 04, 98
FUEL NATURAL GAS	FUEL NATURAL GAS	FUEL NATURAL GAS	FUEL NATURAL GAS
PRIMRY TEMP<C> 29	PRIMRY TEMP <C> 29	PRIMRY TEMP <C> 31	PRIMRY TEMP <C> 31
STACK TEMP <C> 144	STACK TEMP <C> 138	STACK TEMP <C> 282	STACK TEMP <C> 306
% OXYGEN 7,0	% OXYGEN 7,3	% OXYGEN 7,1	% OXYGEN 6,9
% EXCESS AIR 46	% EXCESS AIR 49	% EXCESS AIR 47	% EXCESS AIR 45
% CARBON - DIOXIDE 7,8	% CARBON - DIOXIDE 7,6	% CARBON - DIOXIDE 7,7	% CARBON - DIOXIDE 7,8
PPM CARBON - MONOXIDE 2	PPM CARBON - MONOXIDE 3	PPM CARBON - MONOXIDE 2	PPM CARBON - MONOXIDE 5
PPM NOX 231	PPM NOX 196	PPM NOX 204	PPM NOX 243
PPM SULFUR - DIOXIDE 13	PPM SULFUR - DIOXIDE 11	PPM SULFUR - DIOXIDE 13	PPM SULFUR - DIOXIDE 15
% EFFICIENCY 93,6	% EFFICIENCY 93,8	% EFFICIENCY 85,8	% EFFICIENCY 84,6
% STACK LOSS 6,4	% STACK LOSS 6,2	% STACK LOSS 14,2	% STACK LOSS 15,4
TEST PERFORMED BY	TEST PERFORMED BY	TEST PERFORMED BY	TEST PERFORMED BY

APPENDIX C ENTERPRISE PHOTOGRAPHS

Фото 1 Административный и главный производственный корпуса фабрики
Photo 1 Administrative and Main Production Building of the Confectionery

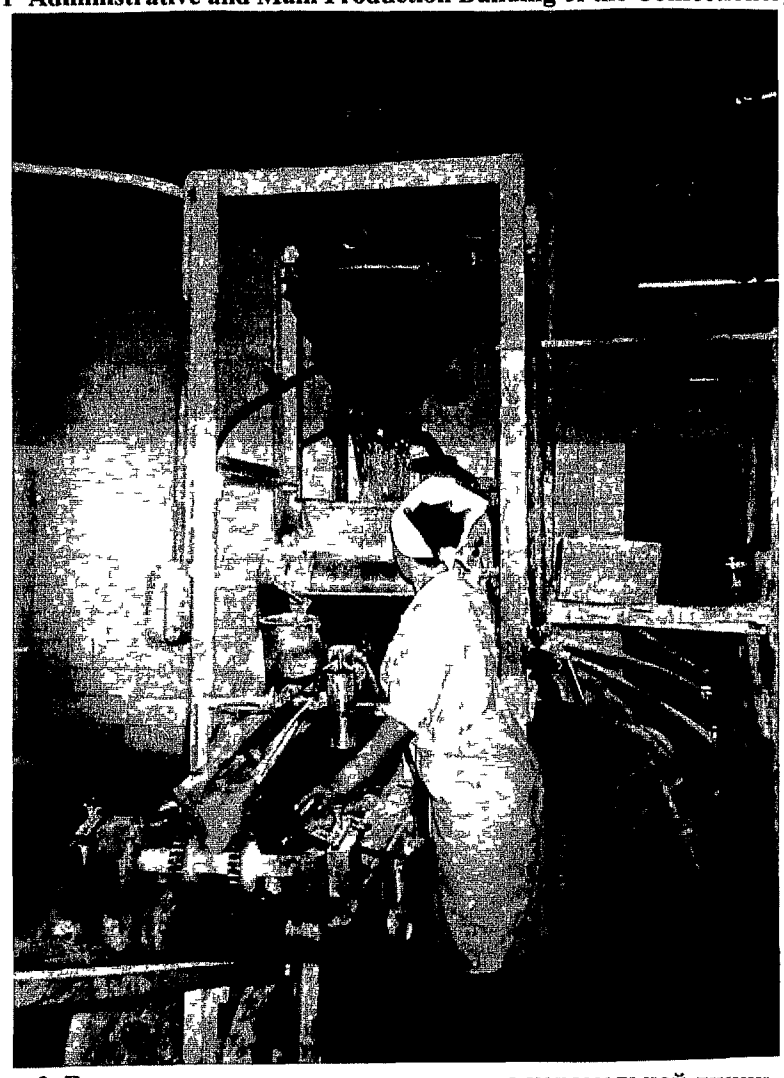

Фото 2 Вакуумно-нагревательная установка карамельной линии
Photo 2 Vacuum-heating plant on the caramel production line

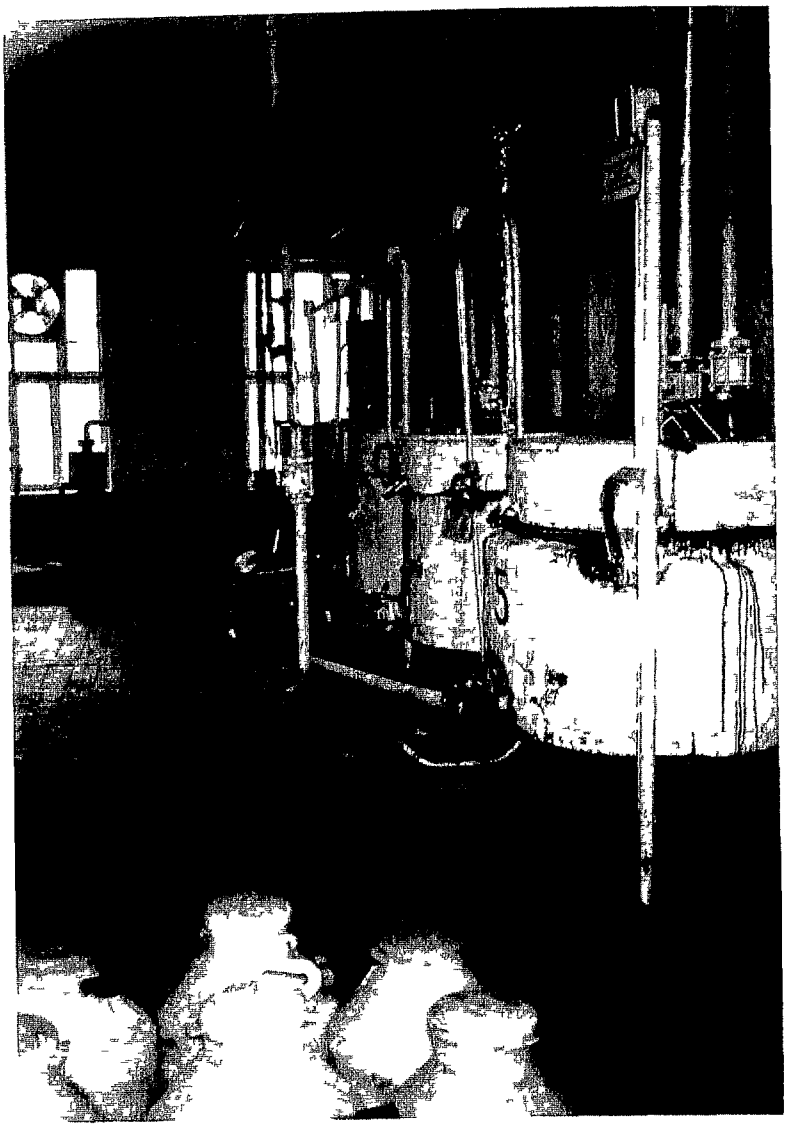

Фото 3 Варочные котлы **Photo3 Cooking tanks**

Фото 4 Обсуждение предварительных результатов с руководством фабрики
Photo 4 Discussion of the preliminary results with the confectionery management

APPENDIX D MEASUREMENT UNITS

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MEASUREMENT UNITS

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

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,