PN-ACD-424

ENERGY AUDIT

PERMMOLOKO COMPANY

Perm Oblast
RUSSIA

Prepared for

US AGENCY FOR INTERNATIONAL DEVELOPMENT
Washington, D C 20253

Prepared by

Hagler Bailly Services, Inc
1530 Wilson Boulevard, Suite 900
Arlington, VA 22209-2406
(703) 351-0300
and
East West Energy Agency
Moscow, Russia

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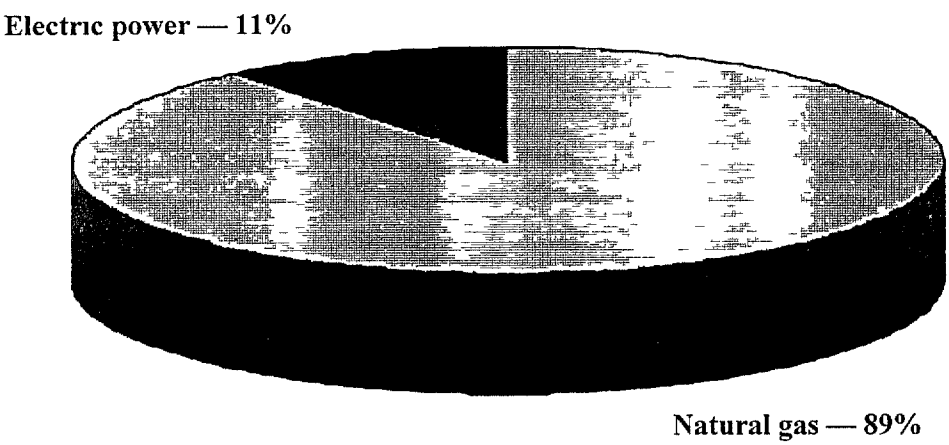
1 Executive Summary

This report shows the results of an energy audit of the Perm integrated milk works ' Permmoloko" completed in March-April, 1998 The job was undertaken in close cooperation with the enterprise power service and its staff We greatly appreciate assistance of the personnel of the lab of power saving of AO Permenergo and of the technical lab of Permgosenergonadzor

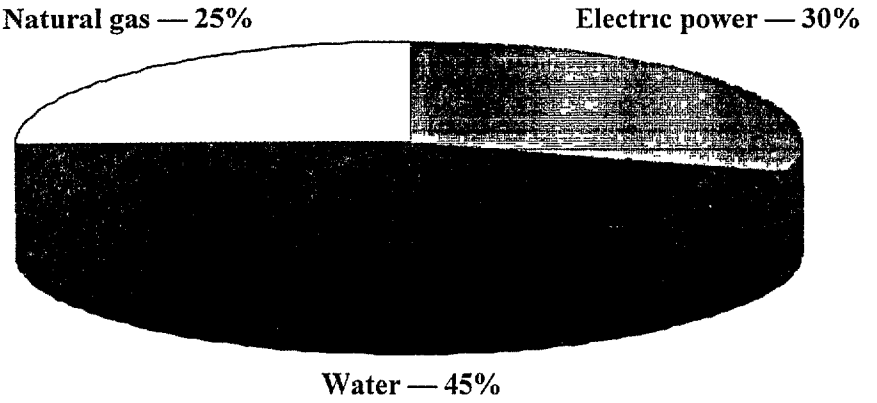
In order to demonstrate the general breakdown of power consumption at the enterprise, the Diagram 1 1 was generated showing a quantitative evaluation of the use of various utilities in power equivalent units The figures of power consumption for 1997 were assumed as a basis It follows from the Diagram that the "Permmoloko" enterprise uses only two types of power resources, namely natural gas and electric power Natural gas accounts herewith, for the main share It is explained by the fact that the enterprise has its own boiler plant that fully covers the needs of both the enterprise and some outside customers for heat power

Diagram 1 1 Breakdown of power consumption



Besides the breakdown of power consumption it is essential to know the breakdown of payments for power resources (shown on Diagram 1 2) Natural gas is a relatively cheap power source and it accounts for less than 25% of total payments The main portion of payments accounts for water supply including water consumption and water drainage

Diagram 1 2 Breakdown of payments for power resources



The results of energy audit show that the following energy-saving measures with repayment term of up to 2 years can be recommended

Table 1 Energy-saving measures

No	Project	Power saving		Project cost,	Payback time,
		GJ	Rb($US)	Rbles	months
Low cost and no-cost projects					
1	Pipelines insulation in boiling houses	2,728 8	20,590 (3,375)	1,936 (317)	2
2	Installation of automatic equipment at water boiling house	8,929 9	67 376 9 (11,045)	3,000 (492)	1
3	Steam pipelines insulation improvement	4,451 6	33,588 (5,506)	9,274 (1,520)	4
4	Return circulation for cooling ammonia compressors in winter with pump replacement	--	62,456 (10,239)	17,660 (2,895)	4
5	Return circulation of air compressors cooling water	--	38,000 (6 230)	25,000 (4,098)	9
6	Installation of accumulating tank in a hot water supply system	9,219	71,400 (11,704)	30,000 (4,900)	5
7	Reduction of air suction at boilers	8,853 6	66,800 (10,951)	30,000 (4,918)	6
8	Feed pump replacement	473	34,650 (5,680)	30,500 (5,000)	11
Medium cost projects					
9	Utilization of de-aerator evaporation heat	16,526	124,400 (20,400)	40,000 (6,500)	4
High cost projects					
10	Re-use utilization of water from process units	--	420,000 (68,600)	76,000 (12,459)	3
11	Application of cationite Ku-2-8 instead of sulphonated coal	--	157,900 (25,892)	136,200 (22,328)	11
12	Switching of heating system from steam to water	15,002	113,188 (18,555)	200,000 (32,780)	22
13	Cooling system reconstruction	--	--	--	--
Total		59,042	1,210,349 (198,418)	599,570 (98,290)	6

The total value shows the aggregate effect of implementation of all measures taking to the account their inter-relation

Implementation of the proposed measures will result in 28% saving of total power consumption and a reduction of payments for power resources and water by 19% It should be noted, that the above list of programs includes no information on the cooling system reconstruction project that will result in substantial reduction of electric power consumption Thus, the enterprise possesses considerable power resources to be saved

2 Introduction

The energy audit has been carried out by a team of the engineers of the East-West Energy Agency, the city of Moscow, within the framework of the "Introduction of Energy-Saving Technologies and Conduct of Market Reforms for Russia" project (Contract No CCN-C-00-152-00) The purpose of the audit was 1) to analyze the use of energy resources and their costs, 2) to identify the points of wasteful energy use, and 3) to determine a set of energy-saving measures at the enterprise

In the course of a visit to the enterprise, ample information on power and production process equipment, equipment operation modes, the working order of power distribution systems, etc was obtained The information has been systematically arranged and presented in this report

The figures have been gathered both through direct measurements, e g equipment capacities of electric power consuming equipment, and through estimates based on project and normative documentation as well as on information supplied by staff Direct measurements were undertaken through up-to-date portable equipment of Western companies The figures collected have been analyzed with the use of spreadsheets providing for fast processing and good readability of the results obtained

3. Description of the Enterprise, Its Basic Equipment and Power Consumption

3 1 General description of the enterprise

The OAO 'Permmoloko" enterprise is located in the city of Perm and is one of major factories that supplies the city and region with milk and dairy products

Within the OAO "Permmoloko", apart from the main factory, there are two affiliated factories, namely the Verkhnemulinsky milk factory and the VKhP "Zakamskoe" located in other parts of the city The main factory and affiliated ones are independently supplied with power This is why this report considers the OAO "Permmoloko" headquarters factory only

At present, the enterprise employs 687 persons

As feedstock, the enterprise uses milk from the surrounding farms, various ingredients, and substandard cheese used in spread cheese production The enterprise has close ties with a number of raw milk suppliers, it even places its equipment on the suppliers' sites in order to secure high-quality feedstock Should milk be supplied cooled down to 8°C to the enterprise, the supplier receives a 5% increase to the milk price

The enterprise has several production lines, i e production of skimmed and fat milk, dietary foods (sour cream, cottage cheese, sour milk, etc), ice cream, sausage cheese, and spread cheese Butter and baby food are produced by the affiliated factories only

The list and amounts of products produced by the factory in 1997 by months are shown in Appendix 1

The changes of production and the changes of average staff over 1994-1997 are shown

Table 3 1 General information on the enterprise

No	Item	Units	1994	1995	1996	1997
1	Main production	tons*	52,539	38,318	37,031	36,953
2	Additional production	tons	1,920	1,022	815	519
3	Cash value of the production	Rbl '000	23,006	67,872	100,971	112,897
4	Average staff	persons	540	577	606	687

* The totals of the products are shown in terms of whole-milk processed

From the table, it is evident that the main production dropped by 30% in 1997 as compared with 1994 It is primarily due to a higher competition on the milk product sales market in recent years The major competitors in the region are the milk factory of Bashkiria, Udmurtia, and Tatarstan whose production cost is lower as a result of subventions on the part of local administrations The region suppliers also dispatch raw milk directly to city enterprises which reduced the sales market of milk produced by the OAO "Permmoloko" by 60% (as estimated by the marketing service)

At present, packed products of the factory account for 40 to 50% of the market share of the city of Perm while dietary foods (kefir, yogurt, stewed sour milk (ryazhenka), etc) for 90%

In 1997, an efficient staff management technology ("Artificial management intellect") is introduced which rendered it possible to increase the level of execution discipline and responsibility of the works staff

In the costs of the products produced, the costs of fuel and power resources and water accounted for 5 6% of the production costs This includes

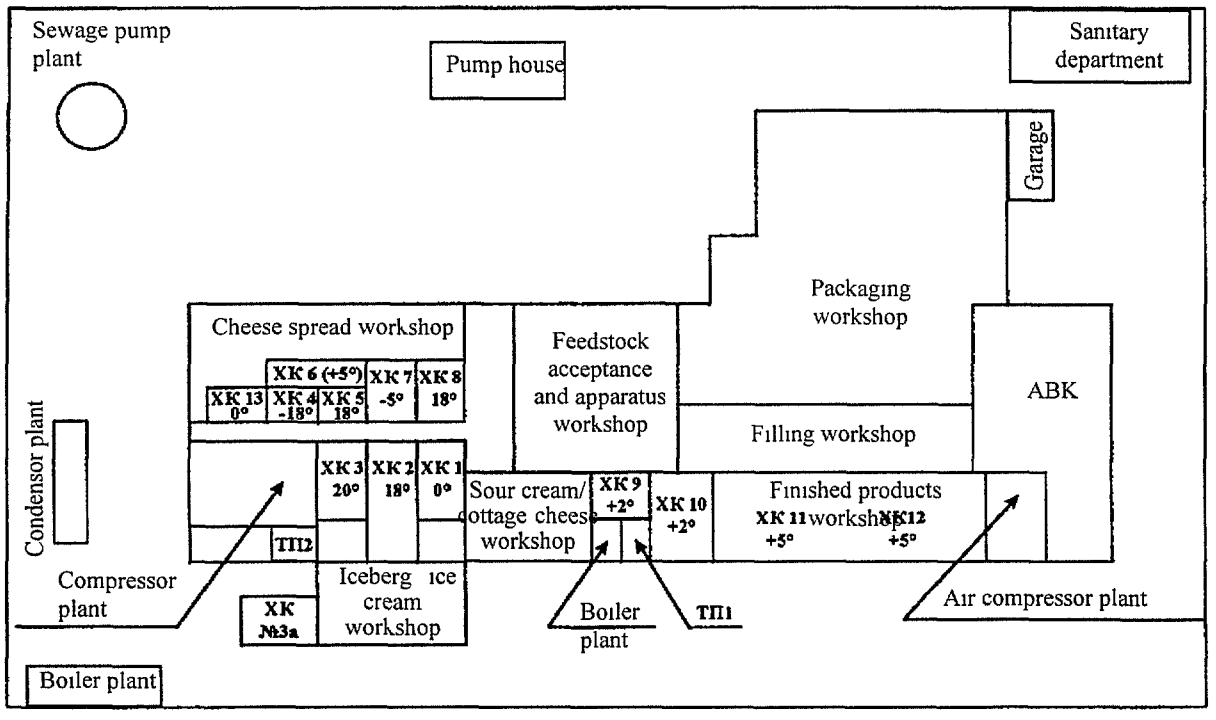
- electric power for 1 7%,
- fuel (natural gas) for 1 8%, and
- water (consumption and discharges) for 2 1%

3 2 General description of the production

3 2 1 Description of the workshops of the factory

The area of the enterprise totals 66,225 5 m^2 The layout of the enterprise is shown at Figure 3 2 1 that identifies the location of main workshops and of stand-alone buildings (boiler plant, pump house, etc)

Figure 3 2 1 Layout of enterprise



The main process equipment is located in a one-story building of the factory constructed in 1967

Table 3 2 1 shows the operation modes of production workshops of the works The power facilities are operational 24 hours a day

Table 3 2 1 Operation modes of the main production lines

No	Name of workshop	Operation hours
1	Packaging workshop	08 00 to 20 00
2	Filling workshop	08 00 to 24 00
3	Feedstock acceptance and apparatus workshop	08 00 to 24 00
4	Finished products workshop	23 00 to 20 00
5	Sour cream/cottage-cheese workshop	08 00 to 24 00
6	Spread cheese workshop	08 00 to 17 00
7	' Iceberg" ice cream production workshop	08 00 to 17 00

3 2 2 Power equipment

Electric power equipment

The enterprise is supplied with electric power by the "Bakharevka" traction substation via two feeders of 10 kV (one being a standby) Due to frequent blackouts at the factory, which were caused by a poor working order of the power cable at a length from the ' Bakharevka" substation to the factory input, a new cable was installed and ended the blackouts Commercial power meters of active (of a SAZU-I670M type) and reactive (of a SR4U-I670M type) power consumed by the factory are installed at the traction substation Similar power meters are installed at each feeder inputs of the factory in the room of transformer substation No 1 (TP1) The electric power supplied to sub-consumer enterprises (winery and shops) is accounted for by the power meters installed In the course of the energy audit, the total power was supplied to the works from the first feeder There is no internal accounting for the electric power distribution because there is no power meters

The works have two transformer substations (of 10/0 4 kV) TP1 and TP2 The TP1 has two transformers TP-1000 and a TP-630, the TP2 has TP-630 and TP560, respectively

Both transformer substations have reactive power compensation devices the TP1 — UKM58-0 4-10-33$^1/_3$UZ (of 100 kVAr capacity) and the TP2 — UKM59-0 4-102 5-(2×30×425)UZ (of 102 5 kVAr capacity) Reactive power is controlled by stages, by automatic connection or disconnection of condenser batteries

The TP1 supplies electric power to the office and amenity building, air compressor plant, boiler plant as well as of the machine shop feedstock acceptance and apparatus shop, sour cream/cottage-cheese shop, and of the filling workshop

The TP2 supplies electric power to the refrigerator compressors, cheese workshop, the city potable water network intake pump house, etc

The sewage pump house has two input feeders one of which is a standby and may be fed both from TP1 and TP2

The lighting and ventilation load of the factory is distributed among workshop input feeders

Cooling agent supply

At the enterprise the cooling system is used for refrigerators for stock and products storage, as well as for cooling of dairy products after pasteurization The latter are cooled by chilling method, i e by

using of secondary cooling agent ice water or brine The main equipment of the cooling system is installed in ammonia compressor station located in the main building

Cooling system operates with no pumps

Cooling equipment mainly consists of single-stage piston compressors (see Table 3 2 2)

Table 3 2 2 List of ammonia piston compressors

Type	Q-ty	Commissioned, year	Capacity, thousand GCal	Drive capacity, kW
AU-200/1	2	1968, 1981	150	55
AUU-400/A	4	1980	300	132
AUU-20/A	2	1980	200	75
AV-100/A	1	1976	75	30
A-350	1	1986	350	200
A-280	1	1986	295	132

In the annex to the compressor building, the evaporators of the three circuits of cooling products after pasteurization are located In the evaporators, ' ice water" and brine are cooled by means of ammonia

Each circuit serves the corresponding process section (see Table 3 2 3)

Table 3 2 3 Secondary cooling agent circuits

1st circuit		
User	–	"Nagema", OPL-25, and "Laval" lines
Secondary cooling agent	–	' icy water" of t = 0°C to 2°C
Evaporator	–	IP320 of a panel type (commissioned in 1988)
2nd circuit		
User	–	4 cottage-cheese coolers of a UPT-5 type, ferment cooler
Secondary cooling agent	–	brine at t = -5°C
Evaporator	–	2 shell-and-tube ITG-250 (1984, 1996)
3rd circuit		
User	–	products cooling tanks, cream for sour cream
Secondary cooling agent	–	"icy water" of t = 0°C to 2°C
Evaporator	–	IP-180 of panel type (1988)

Each evaporator has an automatic float-type ammonia regulator, which regulates the flow rate through the evaporator tubes

The secondary cooling agent circulation is provided by three groups of pumps (see Table 3 2 4)

Table 3 2 4 Pumps of the product cooling system and recirculation system circuits

Type	Number, pcs	Commissioned, year	Capacity, m^3/hour	Drive capacity, kW	Note
Circuit 1					
K-160-30	2	1980	160	22	1 in standby
Circuit 2					
imported (Germany)	2	1989	90	13	1 in standby
K-80-50	2	1993	80	13	1 in standby
Circuit 3					
K-80-50	2	1993	80	13	1 in standby
Recirculation water pumps					
8K-12	3	1967	290	40	summer

Ammonia vapors are condensed downstream of the compressors in the condensor plant The condensors, condensor cooling tower, and recirculation water cooling tower are located 75 meters away from the compressor plant Table 3 2 5 shows the condensor plant equipment installed The ammonia pipeline from the compressor plant to the condensors is laid on trestible support

During summer, an evaporation condensor recirculation water supply system is operational that is integrated with the compressor cooling system The pumps of that system are located in the compressor plant building

Table 3 2 5 List of the condensor units

No	Unit	Commissioned, year	Number, pcs	Capacity, kW	Water, m^3/hour	Fans, No x power (kW)
Ammonia condensers, reflux type						
1	TKA-85	1989	4	313	0 6	2×2 2
2	TKA-140	1992	3	527	1 2	4×2 2
3	IK90	1982	2	≈313	≈0 6	3×2 2
4	IK125	1987	2	≈313	≈0 6	3×2 2
5	AT-2	1996	2	≈140	N/A	4×2 2
Ammonia tube-and shell condensers						
1	KTG-160	1980	3	550	N/A	N/A
2	KTGM-250	1990	1	862	N/A	N/A
3	KTG-85	1991	1	293	N/A	N/A
Water cooling tower						
1	"Rosinka"	1995	2	≈500	N/A	N/A
2	Cooling tower	1967	1		N/A	--

In the ice cream production workshop, located at the compressor plant, a stand-alone NST-8000/100 refrigeration unit (produced by Gram, Germany), of 100,000 kCal/hour capacity, a temperature level of -40°C, and 75 kW drive is installed This unit operates fully automatically and covers the needs of the ice cream workshop for cold generation for the refrigeration of "Iceberg" ice cream storage chamber where a temperature of -25°C is maintained

Apart from the ice cream storage chamber, the enterprise has 13 refrigeration chambers with temperatures ranging from 0°C to -22°C for storing feedstock (substandard cheese) and commercial products (see Table 3 2 6) In the refrigeration chambers, cooling is secured by wall mounted ammonia batteries made of tubes of ∅57 mm with 40 mm band ribs

Table 3 2 6 List of refrigeration chambers

No	No of refrigeration chamber	Volume, m^3	T° of products (working), °C	Load, max, t	Note
1	No 1	1,382	0±1 (0)	20	
2	No 2	2,074	-18 (-18)	20	(in repair)
3	No 3	1,374	-20±2 (-18)	15	(in repair)
4	No 3a (ice cream)	691	-25	N/A	
5	No 4	345	-18 (-18)	15	
6	No 5	345	-18 (-18)	15	
7	No 6	153	0±5 (0)	3	
8	No 7	1,037	0±5 (0)	5	
9	No 8	1,037	-20±2 (-18)	15	
10	No 9	1,037	+4±2 (0)	30	
11	No 10	1,382	+4±2 (0)	30	
12	No 11	1,555	+4±2 (0)	20	
13	No 12	4,147	+4±2 (0)	1,000	
14	No 13	691	+4±2 (0)	5	

Air supply system

The enterprise has its own air compression station Compressed air consumption at the enterprise is relatively small All requirements are covered by the following air compressors

Table 3 2 7 List of air compressors

Type	No	Commissioned, year	Capacity, m^3/min	Pressure, kg/cm^2	Drive capacity, kW
VU-3/8	7	1967	3	8	22
4VU-5/9	2	1992	5	9	37

At the compressor plant outlet, seven 0 5 m^3 receivers are installed and the network pressure is 8 atm Only one 4VU-5/9 compressor is equipped with control automatics switching the compressor on/off depending on the network pressure

The VU-3/8 compressors are water cooled while the 4VU-5/9 is air cooled There is no recirculation water cooling system

Lighting

The workshops lighting system uses different types of lamps The ABK premises are lighted by LB-18 lamps and incandescent lamps The process workshops are lighted by the following lamps LB-40, LB-20, LDTs-80, and DRL of various candle power as well as by incandescent lamps Since DRL lamps are most power-consuming, Appendix 3 shows their placement in the enterprise workshops

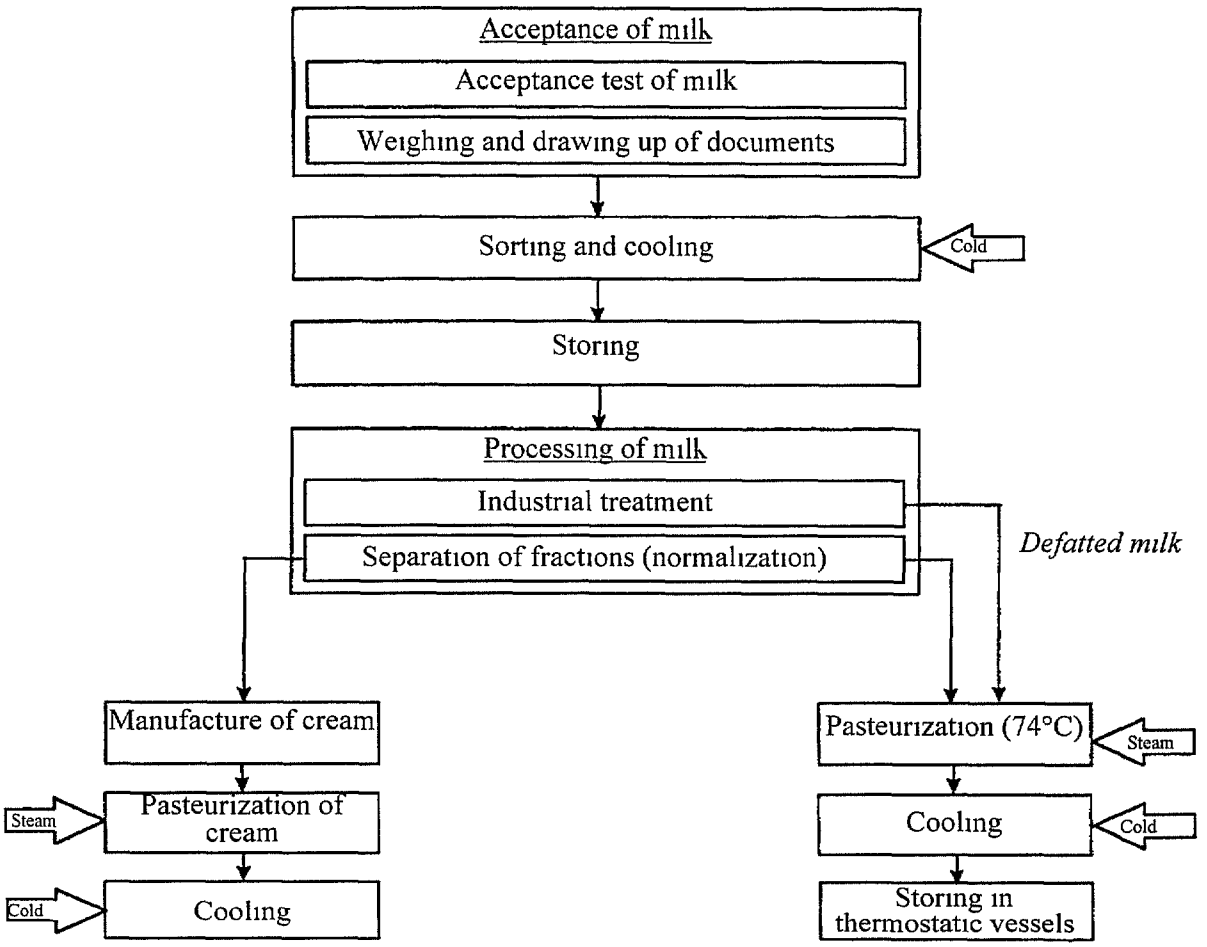
from the manifold is fed to the hot water supply boiler, then fed to the receiver tank and further on to the boiler plant The accumulating tank also receives condensate from the heating system boilers and the hot water system of the Lipovaya Gora settlement

3 3 Description of the production process

3 3 1 Process equipment

The enterprise has several process lines production of defatted and fat milk, dietary products (sour cream, cream cheese, sour milk, etc), ice cream as well as sausage cheese and spread cheese Despite the diversity of the products manufactured, their production processes are generally similar A simplified process flow diagram is shown on the following figures Figure 3 3 1 shows the scheme of acceptance and initial processing of milk

Figure 3 3 1 Initial milk processing



After cooling, the cream reenters the pasteurization, this time in the ice cream workshop, then to vessels cooled with "ice water" with the addition of components cooked in special boilers Then the mix is whipped in freezers, and the product is fed to packaging and further on to a refrigeration chamber

Figure 3 3 2 shows process flow diagram of milk and dietary foods manufacturing

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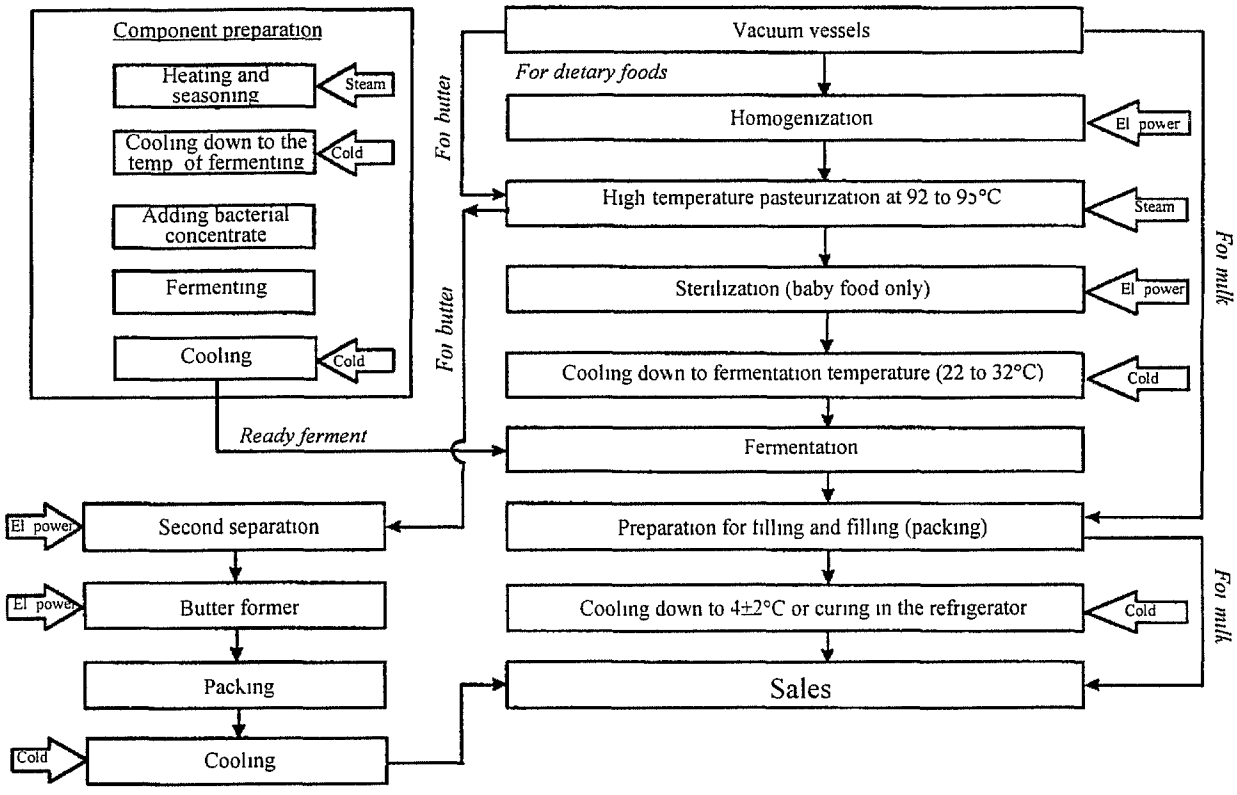
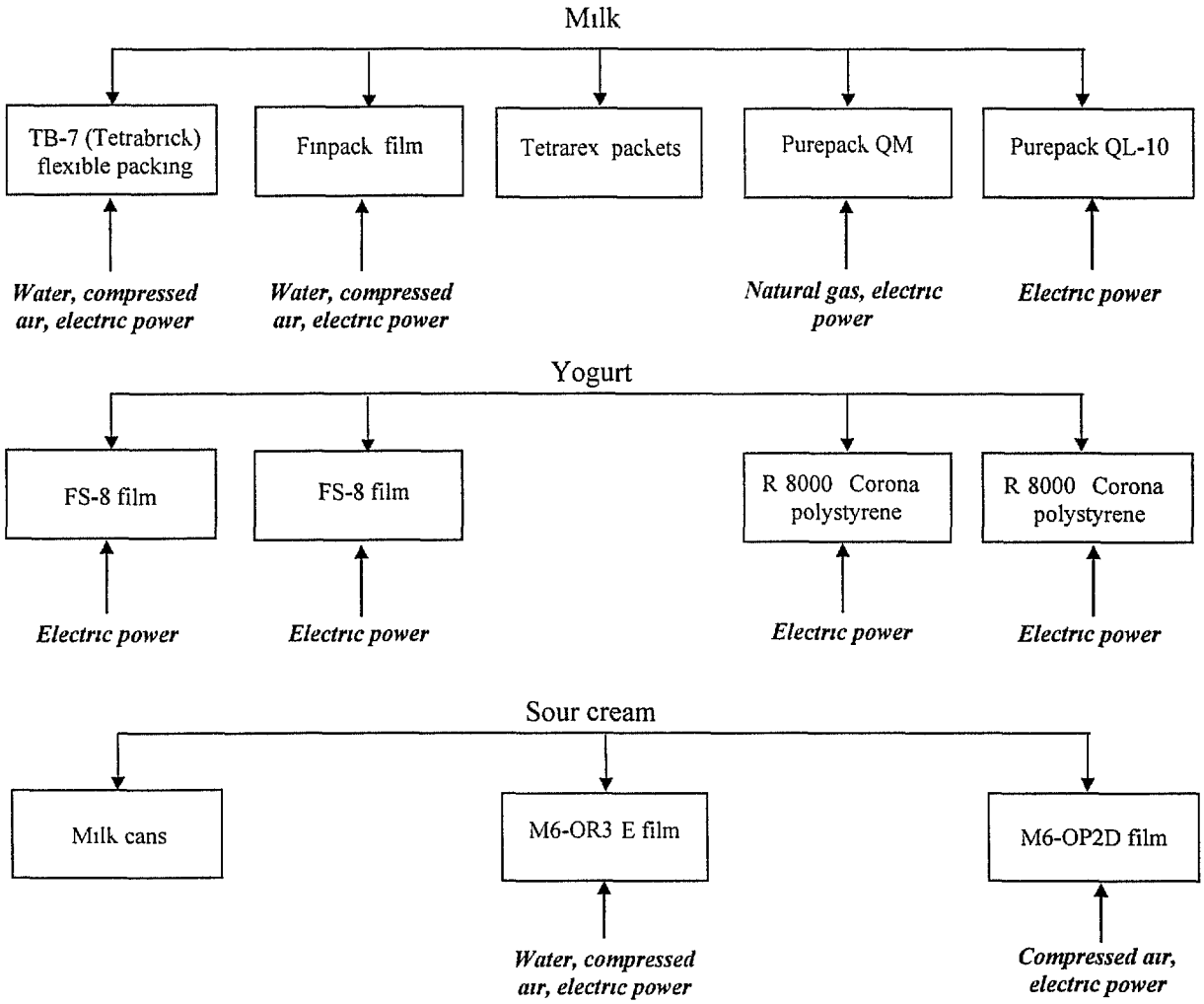
Figure 3 3 2 Flow diagram of milk and dietary foods manufacturing



Packing is quite an energy consuming process, Figure 3 2 3 shows the flow diagrams of the main products packing process

Figure 3 3 3 Flow diagram of main products packing



In the spread cheese workshop of the enterprise, there is a process line for the manufacturing of spread cheese and sausage cheese The works receive substandard cheese, further on, it is manually washed in hot water, milled, and goes into the OPE-400 (3 pieces) melting boilers operating on live steam Then, the spread cheese is packed in four packing devices and is loaded into a refrigerator From the melting boilers, sausage cheese feedstock comes at the "L-5 OKA" unit, then to the smoking plant that operates on wood chips, then it is packed and is loaded to the refrigerator

As the per process flow diagram of the enterprise, its workshops consume a lot of electric power, cold, steam, compressed air (see table 3 3 1), and water

Table 3 3 1 List of the main consumers of compressed air

No	Process equipment	Operation mode, hours per day	Air consumption, m^3/min
1	M6-OP3E automatic filler to film (2 pcs)	12	1 3
2	M6-OP3E automatic sour cream packer (2 pcs)	12	1 3
3	M6-OP2D automatic packer	8	0 3
4	R-8000 automatic packer (2 pcs)	8	0 3

No	Process equipment	Operation mode, hours per day	Air consumption, m^3/min
5	Washing of pipelines without disassembly operations (0 3×2)	2	0 3
6	Pasteurization and cooling units (6 pcs)	12 to 18	1 4
7	Cream pasteurization for sour cream	12	0 3
8	V2-PN (0 8×2) cheese melting boilers	8	1 6
9	Purepack" milk filling line	12	3
10	Sour cream tanks washing	8	0 4
11	Milk stirring in tanks	24	2 5
12	Pneumatic hammer	0 to 24	3
	TOTAL		**16 0**

In the milk production process, steam is used to heat milk products at pasteurization, for disinfection of vessels at the acceptance equipment section by steaming, and for sterilization of ferment components Sterilization takes place in autoclaves at 120°C by live steam under 3 atmospheres Electric power is consumed by the milk transfer pumps, at whipping, homogenization, and packing

4 Analysis of Power Consumption and Operational Modes of Equipment

4 1 Analysis of enterprise power consumption

The OAO "Permmoloko" consumes natural gas, electric power, and water Table 4 1 1 shows information on the commercial products output and power resource consumption change at the enterprise in 1994-1997

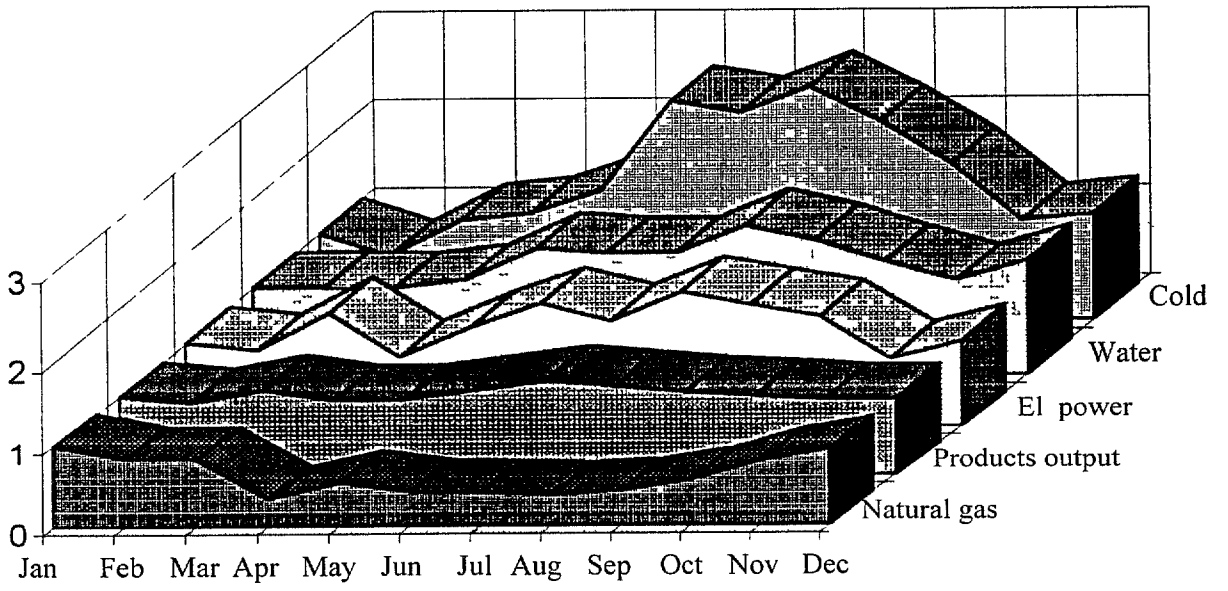
Table 4 1 1 Output and power resource consumption in 1994-1997

Products	Unit	1994	1995	1996	1997
Main	Tons	53,892	39,515	33,462	37,657
Additional	Tons	1,920	1,022	815	519
Power resource					
Natural gas	tons of fuel equivalent	6,522	6,148	6,557	6,495
Electric power	MWh	6,112	6,630	6,327	7,380
Municipal water	m^3	462,511	428,251	422,115	491,348

The table of Appendix II shows information on power consumption by the enterprise in 1997 by months and Appendix III shows information on boiler plant heat and cold output in 1997

The interrelation between power resources consumption and products output in 1997 is shown on Bar chart 4 1 1 Power resource consumption and products output is assumed in arbitrary units in relation to January, 1997

Bar chart 4 1 1 Interrelation between power resource consumption and products output in 1997



As the chart shows, with a sufficiently even output through the year, substantial seasonal difference in power consumption is evident

Table 4 1 2 below shows the power resource tariffs as of March, 1998 These figures have been used in the calculations

Table 4 1 2 Power resources tariffs in 1997

No	Power source	Unit	Rates, Rbl	
			1997	from 01 03 1998
1	Electric power basic rate additional rate for reactive power	 kW kWh kVarh	 66 0 192 0 017	 69 1 0 2637 0 021
2	Natural gas	thous nm^3	293 5*	293 5
3	Municipal water consumption drainage	m^3	 3 96 2 324	 3 96 2 324

Natural gas rate has changed several times over 1997, for more details see the Appendix

Table 4 1 3 Power resources consumption and payments in 1997

Power resource	Unit	Discharge	Power		Cost	
			GJ	%	Thous Rbl	%
Natural gas	t f e	6,495	188,278 2	89	1,616 9	25
Electric power	MWh	7,380	26,568	11	1,919 5	30
Municipal water	000 m^3	491,348	—	—	2,950 6	45
Total			211,226 8	100	6,487 0	100

On Diagrams 4 1 and 4 2 below, the breakdown of power resources consumption in power equivalent and that of payments for power resources consumption are shown

Diagram 4 1 Breakdown of power resources consumption

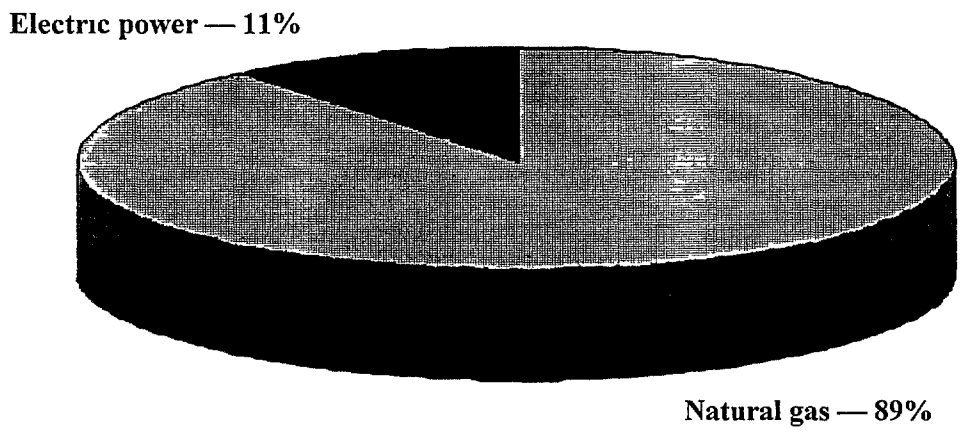
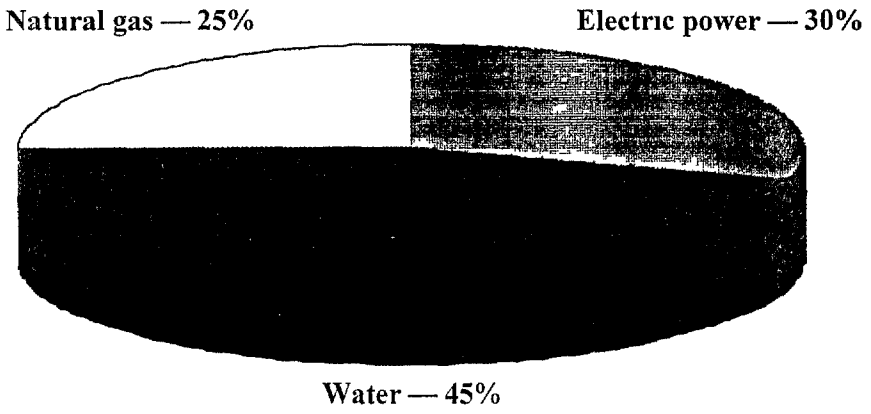


Diagram 4 2 Breakdown of payments for power resources

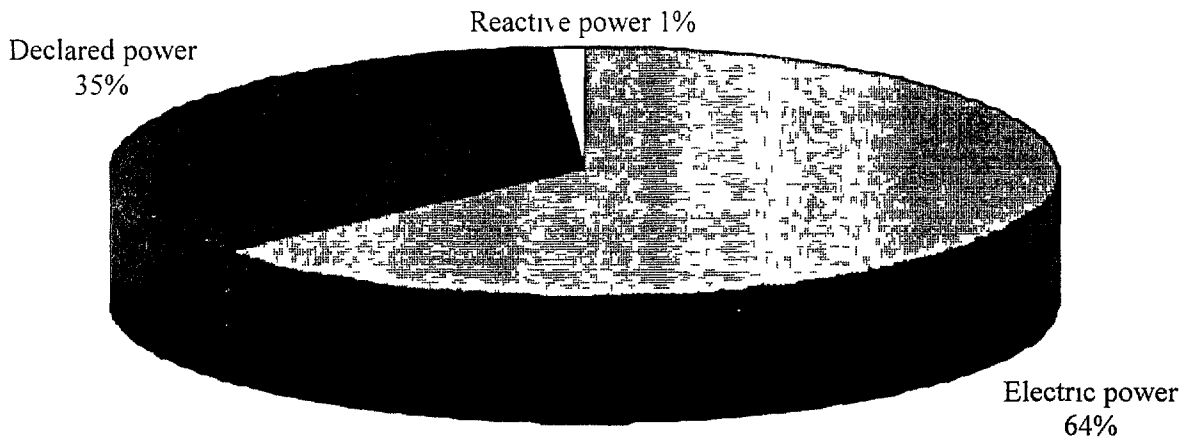


The chart reveals that the major part of payments (about 45%) is for water Effluents coefficient for the plant is 0 88 as of the amount of consumed water

As shown in the Diagram, electric power accounts for some 30% of payments for power resources Under a contract with the municipal utility the enterprise pays for electric power at two-rate tariff and reactive power consumed is paid for according to the readings of a reactive power commercial meter at full existing rate

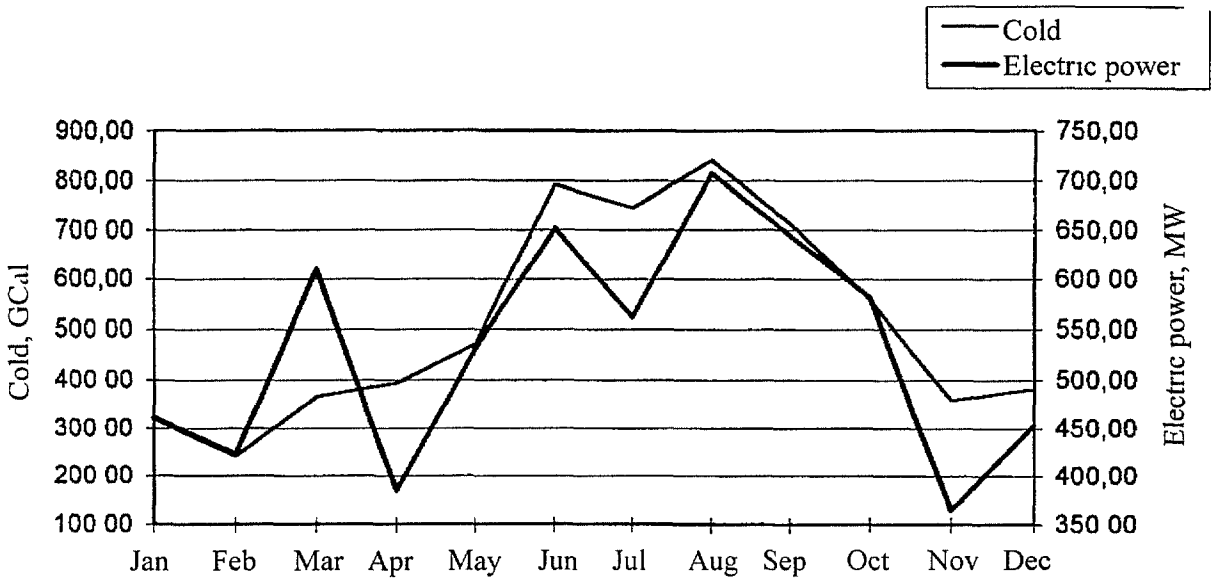
Diagram 4 3 shows the breakdown of payments for electric power

Diagram 4 3 Breakdown of payments for electric power



The refrigerator compressors are the main electric power consumers Figure 4 1 shows electric power consumption and cold generation figures by months

Figure 4 1 Schedule of electric power consumption and cold generation by the ammonia compressor plant in 1997



This Figure shows that both curves are well correlated which is indicative of the fact that it is the compressor plant that mainly determines power consumption of the enterprise A sharp drop in power consumption in April is explained by repairs on the boiler plant for two weeks which suspended the operation of all the boiler plant equipment, network water pumps, and some steam consuming process lines

The mean specific power consumption for cold production is 280 kW*h/GCal

Natural gas accounts for 25% of the payments for power resources Natural gas is used in the boiler plant and in the production process Natural gas consumption is accounted for by two meters one of which is installed in the boiler plant while the other in the filling workshop The annual consumption of natural gas for production process is insignificant, and in 1997, it amounted to 2,460 m^3 or to some 0 04% of the total consumption

4 2 Operation modes of power consuming equipment

Refrigetation supply system

The refrigiration is used at the milk factory both in the production process to cool feedstock, semi-processed products, and commercial products, as well as to cool storage chambers of commercial products Table 4 2 1 below shows the estimated refrigeration consumption by enterprise equipment

Table 4 2 1 Refrigeration energy consumption by enterprise equipment

No	Equipment type	Cold output, kCal/h
Cooling agent — ammonia		
1	Refrigeration chamber No 1	58,728
2	Refrigeration chamber No 2	117,194
3	Refrigeration chamber No 3	130,354
4	Refrigeration chamber No 4	76,274
5	Refrigeration chamber No 5	87,419
6	Refrigeration chamber No 6	34,423
7	Refrigeration chamber No 7	13,771
8	Refrigeration chamber No 8	99,406
9	Refrigeration chamber No 9	49,932
10	Refrigeration chamber No 10	65,893
11	Refrigeration chamber No 11	61 513
12	Refrigeration chamber No 12	224,985
13	Refrigeration chamber No 13	10,021
Total		**1,029,913**

Table 4 2 1 Refrigeration energy consumption by enterprise equipment (continued)

No	Process equipment	Capacity, t/hour	Cold discharge, kCal/hour
Cooling agent — "icy water"			
1	"Vulkan-Laval" cooling and pasteurization line	25	350,000
2	"Nagema" cooling and pasteurization line	25	350,000
3	Cooling and pasteurization line (Votkinsk)	25	350,000
4	"Vulkan-Laval" cream cooler	3	156,000
5	OPU-15 cooling and pasteurization unit (2 pcs)	15	420,000
6	Cooling of milk in the process of lifting it from the pasteurized milk storage	15	60,000
7	Cooling milk and kefir in tanks for 10 hours (14 pcs)	10	56,000
8	Cooling cream used for sour cream production after pasteurization in the tubular cooler	10	120,000
9	Cooling sour cream in the tanks after fermentation for 10 hours (8 pcs)	10	160,000
10	Cooling ferments in the fermentation unit		50,000
11	Cooling the mix for cream cheese in the tanks for 10 hours (9 pcs)	10	180,000
12	Cooling the mix at the TOS-5	5	100,000
13	Cooling cream cheese in the screw cooler	1	17,000
14	Pasteurization of the mix for cream cheese	10	40,000
Total			**2,409,000**
Cooling agent — brine			
1	UPT-5 cream cheese coolers (4 pcs) for 6 hours	5	70,000
2	Cooling ferments following sterilization		50,000
Total			**120,000**
Total for the enterprise			**3,558,000**

The above Table shows that refrigerating of commercial goods storage chambers accounts for 30% of the refrigeration generated by the compressor plant, while preparing of "icy water" accounts for about 67%, and cooling brine accounts for about 3%

It should be noted that the electric power consumption of the ammonia compressor plant clearly shows seasonal character Thus, the compressors account in the winter for 17% of the total power consumption while in the summer their share increases up to 40%

All ammonia compressors operate without automatic controls The plant operator switches them on and off Temperature in the refrigeration chambers is monitored by the readings of a device connected to the thermocouples of the chambers The temperature value in the refrigeration chambers is displayed at a device located in the operator's room

Liquid ammonia is fed from the condensor plant to the plant via a single-pipe line, in the compressor plant the flow is distributed to feed pipelines to the manifolds wherefrom ammonia is supplied to various users Cold supply to the refrigeration chambers is manually operated The operator, judging by the extent of the frosting-up of receiver indication tubes located at ammonia return lines from the chambers in the compressor plant building, opens or closes the ammonia supply valve

The evaporators of secondary cooling agent preparation are equipped with float-type control device to maintain set temperature of "ice water" or brine

The compressor plant operation mode is determined by air temperature in operational refrigeration chambers and is weather dependent, on the other hand it is determined by the number of operational "ice water" and brine circuits In the winter, one to three compressors are operational while in the summer, up to seven are operating

The single-stage piston compressors of the compressor plant are heavily worn and obsolete, and do not always ensure required temperature level in the refrigeration chambers in the summer

In the summer when the discharge pressure, required for ammonia vapor condensing, depends on the ambient temperature, the pressure generated by the compressors is insufficient for proper refrigeration cycle, and the compressors are partially idle Downstream of the condensors, liquid ammonia is fed to the plant at a temperature that is close to one of saturation This is why an intermediate heat exchanger is included in the refrigerator supply system to cool ammonia down to the temperature required It is cooled by a portion of the flow that passes through a choke installed at heat exchanger

The condenser plant equipment includes air-and-water condensors of various types In the summer all air-and-water units operate with water feed, while in the winter, ammonia vapors are condensed through the transfer of heat to the air flow only and water is not fed to the units

Water is not fed to the old condensor tower The ammonia passes through coils being cooled by ambient air

Water is also not fed to the shell-and-tube condensors The ammonia, while passing through the annular space, transfers heat to the air in the tubes In order to allow air to pass through the tubes, the end covers of the thermal exchangers are removed

The recirculation cooling system of the refrigeration compressors is integrated with the air-and-water condensor system and becomes operational when water is fed to the condensor plant only The system operates in the summer only, as a rule, one of three 8K-12 pumps with 290 m^3/h capacity and

40 kW electric drive is used In winter, the compressors are cooled with municipal water, and the recirculation water system is not used

Air compressor plant

The compressor operation mode is as follows during dav time, two VU-3/8 double-stage piston compressors are used To maintain pressure in the main line, a 4VU-5/9 compressor switches on and off, during night time, only one VU-3/8 compressor is used

Heat supply system

The boiler plant of the factory fully provides for the needs of heating and ventilation loads as well as the hot water supply loads of outside consumers These include the car repair station and Lipovaya Gora settlement

The condensate from the car repair station is not returned and is only partly returned from the settlement boiler house It is not metered

Heat generated and supplied to outside users is accounted for by heat meter and a calculation method

Boiler plant

The condensate is fed from the boiler plant receivers to two receivers located near the boiler plant room, and further on, after mixing with raw water, is feed to the chemical treatment units The reagent (sulfuric carbon) is regenerated daily for the first stage and once in four days or more

The laboratory monitors the quality of boiler water at regular intervals, its figures serve as a basis for a decision to periodically blow down of the boilers There is no full and continuous blow down The laboratory analyses condensate in the receiver vessels at regular intervals of time prior to mixing it with raw water in order to prevent feeding contaminated water into the boilers

After the second stage filter the water is fed to two tanks of chemical water treatment and then fed by second stage pumps though the intermediate heat exchanger at 80-85°C to the de-aerator As the instrument survey has revealed, the feed water downstream of the heat exchanger is sent to feed pumps at 85-90°C and further to the boiler's economizer

Evaporation heat of de-aerator is not used and condensate is not returned to the boiler house The air intake to the boiler house burners is provided both from inside and outside of boiling house The amount of air taken from inside of the boiling house is regulated with gate valve As a rule, during the cold season the air is supplied from the outside to avoid suction of cold air to the boiler house

All steam and hot water pipelines inside of the boiler house have no insulation The temperature of the economizer surface and boiler lining in the top part is 50°C and higher

The boilers are controlled manually through variation of gas and air pressure upstream of the burners The gas/air ratio is also controlled manually in accordance with mode charts of each boiler

Heating system

In the past two years, the enterprise made modifications to switch from a steam heating system to a hot water system It now provides 70% of all needs In the near future, it is planned to transfer the rest of the system to water heating Condensate from the remaining steam heating units of the enterprise does not return in full, "dead-end" users do not return condensate

It is worth noting that following the repairs at the administrative-amenity complex, all of the heating system radiators have been encased in decorative panels which impairs the thermal exchange and the efficiency of the whole system

Prior to early 1998, network water of the enterprise was heated in a boiler, but after its efficiency dropped because of the increase of the sediments at the thermal radiation surfaces, a system of a direct injection of steam into the return line was adopted

Hot water supply

Water is heated in the boiler plant by heating municipal cold water with a steam-and-condensate mixture that is returned via condensate pipelines from the enterprise workshops Herewith, should the steam-and-condensate mixture fail to provide the required water temperature (65°C to 75°C) downstream of the boiler, it is afterheated by live steam All condensate collected is fed to a condensate receiver The operator manually maintains a required temperature of hot water There is no automatic control, which results in a substantial deviation of hot water temperature and the discharge of excessive heat power for hot water supply needs It is worth mentioning that there is substantial hot water consumption at the enterprise characterized by large fluctuations This is caused by specific breakdown of water consumption for the production process (flushing tanks, vessels, etc) there are no accumulation vessels in the hot water supply system

Water supply

A large share of the enterprise power resource payment account is for water Water is used for the system of cooling feedstock, semifinished goods, and commercial products following pasteurization, for cooling the compressors, and for boilers make up water both in the cold and hot water supply systems

The intake municipal water is accomplished with pumps of the pump house There is no artesian wells at the factory

At the pump house that supplies the factory with municipal water, only one of five pumps with 15 kW drive is operational

At the sewage pump house, only one pump with 55 kW drive is operational It is switched on and off depending on the effluent water level in the receiver

5 ENERGY SAVING MEASURES

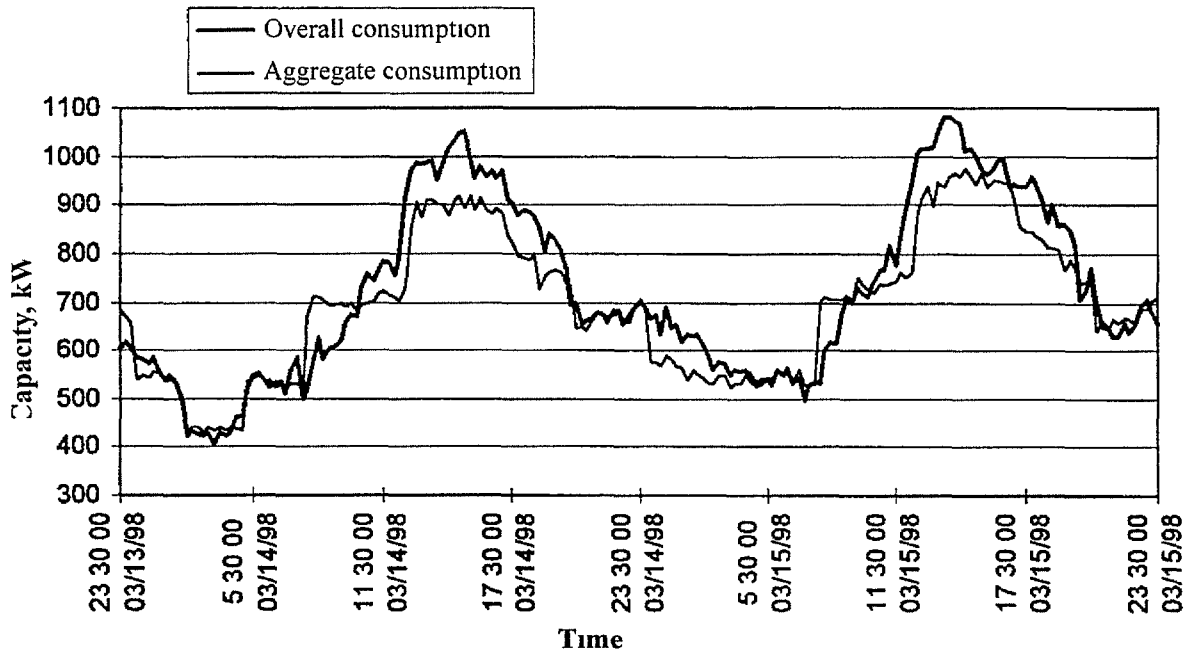
5 1 The results of measurements undertaken at the enterprise

In the analysis of power consumption modes, Energy and Elite power recorders and Fluke multimeter were used In the course of the audit, recording instruments were connected to the service entrance of the enterprise (at the high-voltage side), to the metering device of electric power supplied to the sub-consumer enterprise They were also used at the main electric power consumers one refrigeration compressor in continuous operation, the air compressor plant, and the boiler plant Despite the fact that one of the days was a holiday, the enterprise operated in normal regime A recording device was connected to the sewage plant pumps which were operating in an intermittent mode, and single measurements were undertaken of power consumed at the majority of electric power consumers for the purpose of compiling a power balance sheet and making an analysis of load factors of electric motors Appendix IV shows 24-hours power consumption diagrams of the boiler plant, refrigeration compressors (one of the three of them was operational only), the sewage pump house, and the air compressor plant

Figure 5 1 1 shows a schedule of power consumption for the period from March 14 to 16

The second curve has been obtained by aggregating power consumption by units and separate plants of the enterprise

Figure 5 1 1 Schedule of power consumption for the period from March 14 to 16, 1998



A curve obtained through aggregating the electric power consumed by several enterprise units is sufficiently close to that obtained as a result of recording the electric power by an instrument connected to a common inlet Table 5 1 1 shows a breakdown of power consumption resulting from the graph pickup and capacity measurements of production process equipment installed

Table 5 1 1 Balance sheet of electric power at the enterprise

No	Consumer	Electric power consumption, %
1	**Lighting**	5
2	**Heat supply, including**	**16 6**
	Boiler plant	14 7
	Network pump	1 9
3	**Cold supply, including**	**28 2**
	Compressor plant	17 1
	Cooling towers	7 2
	Secondary cooling agent pumps	3 9 (3 4+0 5)
4	**Production process, including**	**21 4**
	Acceptance equipment job	0 3
	Spread cheese workshop	0 7
	Cottage-cheese/sour cream workshop	4 3
	Finished products workshop	2 8
	Filling workshop	4 1
	Machine shop	2 2
	Fermentation workshop	1 4
	Ice cream workshop	5 6
5	**Air supply**	**6 2**
6	**Ventilation**	**4 2**
7	**Water supply**	**6 7**
	Sewage pump house	1 6
	Pump house	5 1
8	**Outside users and losses**	**9 8**
	TOTAL	**100**

Refrigeration Supply

The refrigeration compressor plant is the main electric power consumer In the course of inspection, up to 6 compressors were operational In the Table 5 1 2 below, the figures of actual power consumed and load factors of the drives of the main electric power consumption equipment of the compressor plant are shown

Table 5 1 2 Power consumption of the equipment

No	Equipment items	Drive capacity, kW	Power consumed (power ratio)	Load factor, %
1	AU-200/1 compressor (No 2)	55	29 (0 58)	52
2	AUU-400/A compressor (No 3)	132	103 (0 79)	78
3	AUU-400/A compressor (No 5)	132	95 (0 82)	72
4	AUU-20/A compressor (No 8)	75	68 (0 86)	90
5	AU-200/1 compressor (No 10)	55	20 (0 48)	36
6	AV-100/A compressor	30	11 (0 59)	37
7	6K-12 compressor, first circuit	22	14 (0 77)	64
8	4K-8 compressor	13	11 (0 65)	85
9	Condensor plant fans	N/A	52 (0 64)	--

A visual inspection of pipelines from the compressor plant to the condensor plant at a section of about 75 m revealed that the pipeline feeding ammonia vapors from the compressors was not insulated The measurements done indicated that the pipe temperature downstream of the compressor plant was about 100 to 120°C (up to 150°C by summer time), After having passed an open section, the temperature of the pipe upstream of the condensors was of the order of 40°C which was explained by the cooling through the ambient air (the temperatures were measured by an "Omega" digital thermometer at about 0°C of ambient air)

The liquid ammonia pipe insulation has faults, and the distribution pipes up to the inlet to the trestlework have no insulation at all A total 50 m of pipes with an average diameter of 50 mm have no insulation At the moment of inspection of the condensor plant, the temperature of the liquid ammonia downstream of the condensors was 4 to 6°C In summer missing insulation results in refrigeration losses from the liquid ammonia pipeline

Cooling chambers were checked during the audit Two chambers were under repair The audit of the other (operating) chambers revealed that the chambers with positive temperature are not equipped with curtains and the doors are not tight Chambers with negative temperature have, as a rule, doors in good condition

In Coolers 4, 5 and 6 the insulation of walls, ceiling and floor has been improved Insulation material was repaired Similar repair works are in process in Cooler 3 Low temperature Cooler 2 is scheduled for insulation replacement Improvement of the insulation of the coolers will result in elimination of previously observed ground freezing and avoid cold leaks to adjacent coolers and rooms

During the coolers inspection all of them had ice buildup on ammonia batteries, which greatly reduces their efficiency

The cooling compressor station is located in on the building with cold consumers, so the length distribution pipelines is not substantial

As a result of the inspection, it should be noted that the wear and obsolescence of compressor equipment, lack of automatic devices for adjustment of compressor station performance and keeping of needed temperature in coolers makes the cooling system inefficient The reconstruction of the entire system should be considered as an option of its performance improvement

Air supply system

In the course of the inspection of the compressor plant, the air temperatures in the injection line were measured (130°C) The average air consumption in the air supply system for the period of time inspected (March 13-14) was about 7,680 m^3/24 hours (4 hours of net time within 24 hours, the 5 m^3 compressor and 36 hours 3 m^3 compressors were operational) The plant's maximum demand in compressed air is 16 m^3 (refer to Table 3 3 1) As numerous consumers of compressed air were out of operation at the moment of inspection it can be concluded that there were leaks in distribution system of compressed air

Boiler plant

The boiler house is the major consumer of natural gas at the plant As there are two similar boilers in the boiler house, their efficient use during the year is rather complicated Most of the year (fall until spring) when the steam production has to be at the level of 10-13 t/h One boiler is not sufficient to cover this demand, therefore two boilers are in operation at minimum loads that sometimes are even below those available in a process card At such loads the boilers' efficiency is 2-4% lower than at nominal loads

The boilers were tested during the audit with the purpose of evaluating the efficiency of their operation It included measuring the composition of fume gases up- and downstream of the economizer, the percentage of CO_2, O_2, and CO, and the temperature of gases BACHARAH electronic gas analyzers were used for measuring

The results of the tests and estimates of thermal losses performed are shown in the Appendix V

Test results revealed the following

- Gas-air ratio in the burners at the boilers' working regimes under process card and beyond its limits (at a lower load) in total provide efficient gas burning (initial signs of CO in stack gas)
- Substantial air suction to boilers line was revealed for Boiler 1 it occurs upstream of economizer and comprise 120-180%, whereas for Boiler 2 suction is big both upstream of economizer (90-110%) and especially in the economizer itself (200-250%) Such substantial air suction results in acute increase of heat losses with stack gas as well as in additional load on boilers' smoke exhaust system
- Sealing of hatches and visible leaks from Boiler 1 did not result in air suction decrease that reveals the major air suction through the walls of boilers
- Air suction decrease to standard values will result in 2-7% fuel saving

To evaluate the real values of steam production in a boiler house feed water the flow was checked within two hours for Boiler 1 and 1 5 hours for Boiler 2 Observation revealed good correlation of the test and flow meter values for Boiler 1 and 20% overrated test values to compare with flow meter values for Boiler 2 The total steam production by two boilers was 9 5 t/h

Additionally with the help of a Fluke multipurpose meter the measurement of electric power consumed by feed water pumps, supply and circulation water pumps for heating and hot water supply systems were performed

Feed water supplied to boilers after deaerator, heating system water, as well as electric power consumed by the pumps of feed water, system and circulation water for heating and hot water supply system were measured with the use of the Panametrics flow meter

Heating and ventilation system

A visual inspection and the measurements completed on the heating and ventilation system have shown that it is in poor bad working condition or missing insulation coating at substantial lengths of the pipes of the heating system, hot water supply system, the condensate return from various plants and hot water supply as well as an entirely missing insulation at the feeding water pipelines and the economizers Total length of non-insulated pipeline sections is about 450 m which, given high temperatures of their surfaces (up to 100°C and above) results in big thermal losses to the environment

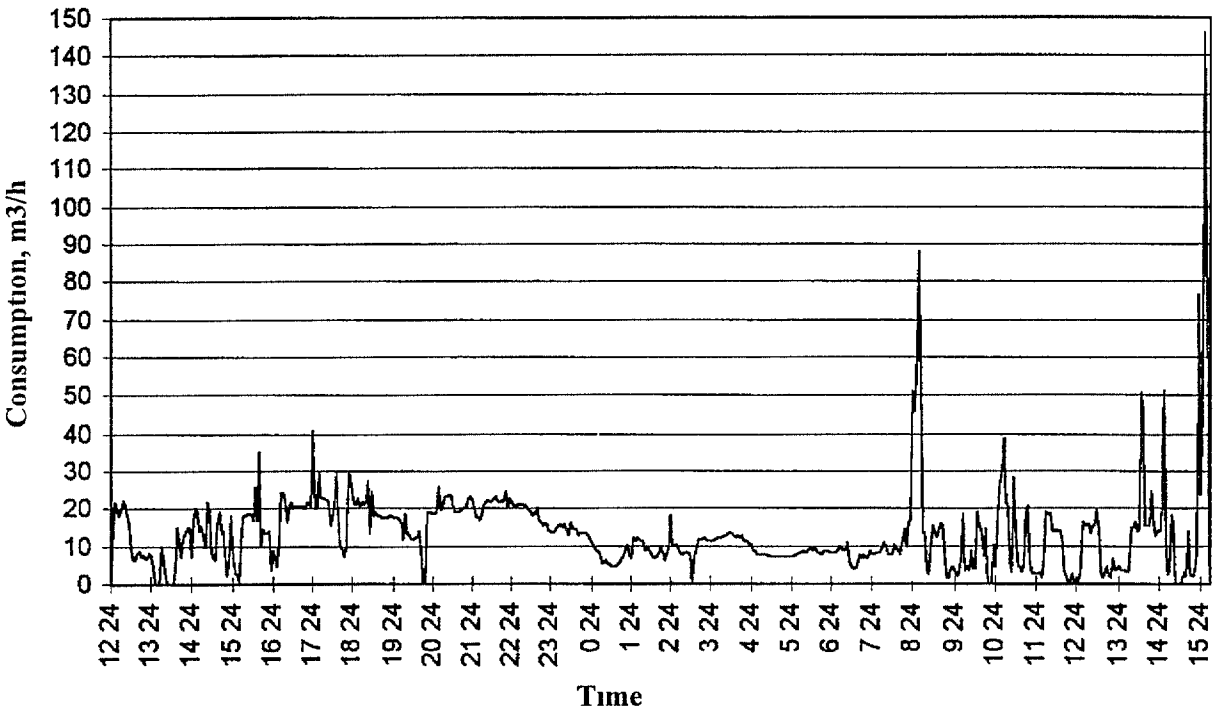
The results of the above measurements and evaluations of the thermal losses are shown in Table of the Appendix VI

The following measurements were done to evaluate the loads on the heating system flow rate in a return line of condensate from the steam heating system (800 kg/h), and the flow rate of system water (70 m^3/h) and its temperature in a feed and return lines (61 5°C and 54 3°C, respectively) In accordance with the evaluation the load on the heating system with regard to losses at "dead-end" lines and in distribution system (600 kg/h) is 6, 980 GCal/year

Hot water supply system

In order to analyze the breakdown of consumption of the hot water supply system and to evaluate losses due to the absence of hot water accumulating tanks, the water consumption for hot water supply needs was measured by a Panametrics instrument Figure 5 1 3 shows a 24-hours schedule of water consumption

Figure 5 1 3 Water consumption for hot water supply needs



The obtained results demonstrate acute fluctuations of hot water consumption from 0 to 90 m^3/h Daily water consumption is 330 m^3 Assuming that the mean temperature of water heating in a boiler is 60°C the estimated heat load on the hot water supply system is about 7,227 GCal/year or 17 9% of total heat production

On the basis of the available data on the consumption of power resources, as well as of the measurements performed, a heat balance for the entire of the plant was prepared as shown in Table 5 1 3

Table 5 1 3 Heat energy balance of the enterprise

No	Consumer	Yearly power consumption	
		GCal	%
1	Heating	6,980	17 2
2	Hot water supply system	7,227	17 9
3	Process	8,702	21 5
4	Boiling house (own consumption)	2,662	6 6
5	Outside consumers	14,883	36 8
	Total	40,454	100

Water supply system

On the basis of the performed measurements and calculations, as well as on reported data on water consumption in 1997, the water consumption balance was prepared as shown in Table 5 1 4

Table 5 1 4 Water consumption balance of the enterprise

No	Consumer	Yearly water consumption	
		Thou m^3	%
1	**Boiling house, including**	**70 2**	**14 2**
	Steam production*	50 2	10 2
	Filters regeneration	20 0	4
2	**Hot water supply system**	**190 5**	**38 8**
3	**Sanitary needs**	**17 5**	**3 6**
4	**Ammonia compressors**	**12**	**2 4**
5	**Air compressors**	**6 5**	**1 3**
6	**Process with regard to losses**	**194 6**	**39 7**
	Total	**491 3**	**100**

*including condensate return (44%)

5 2 Possible energy saving measures

The inspection and instrumental measurements done revealed a potential of improving the efficiency of power use at the enterprise

Refrigeration supply system

The refrigeration equipment is the main electric power consumer at the enterprise Missing automatic controls, heavy wear of the basic refrigeration equipment, and an improper cold supply system result in substantial power consumption A complete refurbishing of the ammonia compressor plant with a full replacement of the present compressors, arrangement of two independent circuits operating at their own temperature level, and provision of the cold supply to its users with automatics is one way for improving efficiency

The installation of an intermediate heat exchanger downstream of compressor station on the discharge line would permit the plant to reduce the ammonia vapor temperature to a great extent upstream of condensers and to decrease their load adequately Utilization of heat potential of compressed ammonia vapor would provide heating of 53 tons of hot water per day to 70°C and saving of 143 thou m^3 of natural gas per year Calculations are attached in Appendix IX Hot water could be used in the boiler house, in the hot water supply system and water heating system, but with regard to ammonia toxic properties this project can be recommended after additional analysis and it supposes considerable investments that makes it unprofitable under current prices for gas

Air supply system

The heat of compressed air in the air supply system can be used for heating and hot water supply Calculations revealed that the utilization of compressed air heat would result in saving of about 6,400 m^3 of natural gas that is equivalent to 1,880 Rb ($308) With such saving the installation of a heat exchanger on an air line downstream of the compressors would have a long payback period, that currently is not acceptable

Boiler house

The major heat losses in the boiler house result from the inefficient performance of the boilers due to large air suction along the stream (in Boiler 2 in particular), as well as both boilers are of the same size range The latter fact makes the boilers utilization inflexible in terms of required load A considerable number of hours per year both of the boilers is operated at a minimum load level and even below Thus, the heat losses resulting from air suction are aggravated with the increasing indirect heat losses to the environment resulting in large fuel overconsumption by the boiler house The actually measured efficiency was 87 5% and 84% for Boilers 1 and 2, respectively, that is 4-8% below the nominal level As the tests have revealed the situation is complex due to the fact that major suction occurs through the boilers lining that can probably be eliminated only in the case of reconstruction of its elements (refer to Project 7)

The evaluation of the replacement of the current Boiler 2 with DKVR 6 5/13 boiler revealed that natural gas saving resulting from the efficiency increase by 6-8% will not permit to pay back capital investments for a new boiler in a short time

The large heat losses result from non-use of vapor heat of the deaerator comprising about 800 kg of steam per hour (0 45 GJ/h) Usually this heat is utilized for preliminary heating of chemically treated water prior to de-aerator, but such heating is currently performed with feed water The latter has a positive influence upon pumps performance and permits it to utilize stack gas heat to a full extent (feed water from heat exchanger is sent to the economizers at a lower temperature)

On the other hand air for burning can be supplied both from the outside and from the top part of the boiler house In this case boiler efficiency increases

The combustion air intake can be made both from outside and from the top of boiler house The negative feature is cooling of the boiler house area in the winter due to the replacement of inside warm air with the cold outside one that results in considerable fuel overconsumption To increase the boilers' efficiency, it is proposed to raise burning air temperature One option is the installation of a steam air heater in the air intake line from the outside Prior to the air heater it is recommended to install a unit mixing inside and outside air A gate valve can be used for adjustment of warm-cold air ratio with a range from 0 to 100%

This project implementation would permit the system to send warm air to the burners in winter

Capital investments will mainly include the installation of an air heater and a steam pipeline from the de-aerator, as well as some reconstruction of the air intake pipes (refer to Project 9)

Considerable heat losses in the boiler house are also related to the entire lack of insulation of all pipelines both steam lines and feed water lines Their insulation will require inconsiderable capital investments and will result in good savings (refer to Project 1)

Sulphonated coal is used as an agent in the chemical water treatment units Its replacement with cationite, despite the higher price of the latter, will result in considerable water savings and consequent reductions of a number of chemical regeneration and carry-over (refer to Project 11)

Heating system

The switching of the heating system from steam to water is in process Two thirds of the system is already using water Project 12 discloses the efficiency of a new heating system

The study revealed additional opportunities of power saving through further improvement of the heating system

- Replacement of the system pump with a one of lower capacity, especially after the necessary elimination of inoperable boiler where a system pump discharges water Pressure drop at this boiler is about 2 atm
- Elimination of the low efficient heat screens in the receiving shop, etc
- Enhancement of the heat radiation in the administrative-amenity buildings by removing the casings
- Insulation of non-insulated pipelines and repair of damaged insulation

Note that there are some improvements in the entire heat power system Elimination of the steam heating will result in reduction of condensate losses by approximately 600 kg/h and will improve steam utilization efficiency due its direct injection into water that will also reduce its consumption Elimination of the steam-condensate mix that is currently used for heating water will improve heating system with only the steam supply from the boiler house Thus, it is possible to reduce both the steam production and consumption at the plant

Water supply system

The audit revealed extremely high water consumption by the plant as a whole Reduction of water consumption is possible by switching of the cooling system of the process equipment (air compressors) to the circulation cycle (refer to Project 5), by the use of the currently available system of water cooling of ammonia compressors in the winter (refer to Project 4), and by the repeated use of water from the systems of cooling and heating of different process units, such as, pasteurization units The probability of milk getting into water is actually eliminated due to high water pressure The permanent monitoring of milk content in water can be performed with the help of a indicator-detector of water contamination with a specially adjusted alarm system The expenses related to purchasing of such an indicator are about $6,000 (refer to Project 10)

One more water saving project is the installation of a hot water accumulating tank that will result in reduction of steam consumption (Project 6)

5 3 *Energy saving measures proposed*

Project No 1

Insulation of pipelines in steam and water boiler houses

1 **Saving**

Annual gas saving	70 15 thou m^3, 20,590 Rb (3,375 $US)
Total saving	20,590 Rb (3,370 $US)

2 **Expenditures (including VAT)**

Mineral wool	1,210 Rb (198 $US)
Insulation installation	726 Rb (119 $US)
Total expenditures	1,936 Rb (317 $US)

3 **Payback time**

Recommendations
Insulation of non-coated segments of pipelines in boiler houses

Description
To reduce heat losses through the non-coated segments of feed water and circulation pipelines, steam lines and valves they are to be insulated that will result in saving of 70 15 thou m^3 of natural gas

Anticipated saving
At current gas rates the saving of 70 15 thou m^3 of natural gas is equivalent to 20,590 Rb (3,375 $US)

Necessary investments
To insulate non-coated segments of pipelines of boiler houses totaling 490 m it is necessary 2 8 m^3 of mineral wool Estimated cost of insulation materials (mineral wool and pergamyn) as well as of their installation is 1,936 Rb (317 $US) including VAT

Payback time
Payback time is 2 month Project scale does not make necessary to estimate the internal rate of return

Terms
The Project can be implemented immediately

Technical risks related to variability of quality and amount of commercial products
No data on this type of risks is available

Initial data and calculations
The initial data include measurements of the length, diameters and surface temperatures of non-coated pipelines in a boiling house (refer to Appendix VI)
Total heat losses from non-coated pipelines of boiler houses and boilers are 84 7 kW
Efficient insulation thickness for these pipelines is about 30 mm After insulation heat losses for the coated segments of pipelines will be about 11 5 kW
Thus, insulation will result in saving of about 73 2 kW that is equivalent to 70 15 thou m^3 of natural gas or 20,590 Rb (3,375 $US) in cash

Estimated efficiency is assumed to be 85%
Estimation of heat losses through non-coated segments of pipelines and calculation of insulation efficient thickness was performed by reference tables

Project No 2

Installation of automatic control devices at the boiler of hot water supply system

1 **Saving**

Annual gas savings	229 56 thou m^3,	67,376 9 Rb (11,045 $US)
Total savings		67,376 9 Rb (11,045 $US)

2 **Expenditures (including VAT)**

Automatic devices	3,000 Rb (492 $US)
Total expenditures	3,000 Rb (492 $US)

3 **Payback time**

Recommendations
Installation of automatic control devices at the boiler of hot water supply system

Description
To maintain hot water temperature downstream of the boiler and to improve the efficiency of steam utilization it is recommended to install an automatic control device on the line of a heating agent that will result in saving of 229 56 thou m^3 of natural gas

Anticipated saving
At current gas rates the saving of 229 56 thou m^3 of natural gas is equivalent to 67,376 9 Rb (11,045 $US)

Necessary investments
Estimated cost of automatic control device with its installation is 3,000 Rb (492 $US) including VAT

Payback time
Payback time is 1 month Project scale does not make necessary to estimate the internal rate of return

Terms
The Project can be implemented immediately

Technical risks related to variability of quality and amount of commercial products
No data on this type of risks is available

Initial data and calculations
Visual inspection revealed that the temperature of hot water sent to the consumer was overrated by 10-15°C and higher As a result heat overconsumption occurs in the course of water heating Annual power saving will be as follows

$$Q = 330\ m^3 \times 365 \times 15°C = 1{,}806\ 750\ GCal,$$

that is equivalent to saving of 229 56 thou m^3 of natural gas (estimated efficiency is assumed 85%) Annual gas saving in cash is 67,376 9 Rb (11 045 $US) Estimated efficiency is assumed 85%

Project No 3

Improvement of steam pipelines insulation

1 **Savings**

Annual gas savings	114,438 thou m^3,	33,588 Rb (5,506 $US)
Total savings		33,588 Rb (5,506 $US)

2 **Expenditures (including VAT)**

Mineral wool	2,707 Rb (444 $US)
Steel zinc-coated sheets	3,089 Rb (507 $US)
Insulation installation	3,478 Rb (570 $US)
Total expenditures	9,274 Rb (1,520 $US)

3 **Payback time**

Recommendations
Replacement of inefficient insulation of steam pipelines from the boiler house to boiler

Description
To reduce heat losses through the inefficiently insulated segments of steam pipelines their insulation is to be replaced that will result in saving of 114,438 thou m^3 of natural gas

Anticipated saving
At current gas rates the saving of 114,438 thou m^3 of natural gas is equivalent to 33,588 Rb (5,506 $US)

Necessary investments
To insulate 300 m long pipelines from the boiler house to the boiler it is necessary 7 5 m^3 of mineral wool and 660 kg of steel zinc-coated sheet 0 8 mm thick Estimated cost of insulation materials (mineral wool price is 360 Rb/ m^3 and zinc-coated steel price is 3900 Rb/t) as well as of their installation (1 6 coefficient of the total cost of the materials) is 9,274 Rb (1,520 $US) including VAT

Payback time
Payback time is 4 months Project scale does not make necessary to estimate the internal rate of return

Terms
The Project can be implemented immediately

Technical risks related to variability of quality and amount of commercial products
No data on this type of risks is available

Initial data and calculations
The initial data include the length (300 m), diameter (114 mm) and surface temperature (160°C) of a steam pipeline Insulation efficiency is currently about 50% with heat losses of about 135 kW
Efficient insulation thickness (mineral wool) for these pipelines is about 70 mm After installation of new insulation with steel sheets total heat losses will be reduced to 15 6 kW Thus, it will result in saving of about 119 4 kW or 1,045,944 kW*h per year that is equivalent to 114,438 thou m^3 of natural gas or to 33,588 Rb (5,506 $US) in cash
Estimated efficiency is assumed to be 85%

Estimation of heat losses through non-coated segments of pipelines and calculation of insulation efficient thickness was performed by reference tables

Project No 4

The use of a system of return circulation for cooling ammonia compressors in winter with pump replacement

1 **Saving**

Annual water savings	11,316 thou m³,	64,556 Rb (10,583 $US)
Electric power consumption	7,973 kW*h,	2,100 Rb (334 $US)
Total savings		62,456 Rb (10,239 $US)

2 **Expenditures (including VAT)**

Two KM50-32-125 pumps	15,000 Rb (2,460 $US)
Pipeline construction	14,000 Rb (2,2957 $US)
Total expenditures	29,000 Rb (4,775 $US)

3 **Payback time**

Recommendations
The use of circulation cooling system of the ammonia compressors in winter purposed for water saving

Description
To create circulation cycle it is necessary to install of two pumps and a system of pipelines permitting to use the system without water supply to ammonia condensers

Anticipated saving
At current water rates the saving of 11,316 m^3 of water with regard to expenditures on electric power consumed by a pump of circulation cooling of compressors is equivalent to 62,456 Rb (10,239 $US)

Necessary investments
As of the available information an installation of a new pipeline might be necessary for autonomous operation of a circulation loop for compressors cooling (cooling water pool - pump - water cooling tower Rosinka - pool) avoiding water pumping to ammonia compressors A new pipeline maximum possible length is 140 m The expenditures on construction of a new pipeline at a price of 1 m of ∅80-100 mm pipe of about 50 Rb will comprise about 14,000 Rb (2,295 $US)
With regard to the cost of two KM50-32-125 pumps (2 × 7,500 Rb) total capital investment will be 29,000 (4,755 $US)

Payback time
Payback time is 6 months Project scale does not make necessary to estimate the internal rate of return

Terms
The Project can be implemented immediately

Technical risks related to variability of quality and amount of commercial products
No data on this type of risks is available

Initial data and calculations
On the basis of the data of performance of separate ammonia compressors it is possible to evaluate the amount of water consumed from November till March when the system of

circulation cooling of compressors was not used Compressors No 1, 2, 8, 9, 10 and 3, 4, 5, 6, 7, 11 consume 1 m^3 and 2 m^3 of water respectively Total amount of water consumed from a city system for cooling in winter of 1997 is 11,316 m^3 Possible saving with regard to payments for water consumption and water discharge is 64,556 (10,583 $US) Saving evaluation assumes that the amount of make-up water is 5% of total cooling water consumption To reduce electric power consumption it is possible to consider an option of replacement of a high capacity pump purposed for performance in summer with the other one of lower capacity At pump capacity of 2 2 kW with a discharge flow rate of 12 5 m^3 and the head of 20 m at 24-hours-a-day performance during 3,624 hours the expenditures will total 2,100 Rb (344 $US) Thus total annual saving of power resources will comprise about 62,456 Rb (10,239 $US)

Project No 5

Arrangement of a return circulation of air compressors cooling water

1	**Savings**		
	Annual water savings	6,307 m^3,	38,000 Rb (6,230 $US)
	Total savings		38,000 Rb (6,230 $US)
2	**Expenditures (including VAT)**		
	Total expenditures		25,000 Rb (4,098 $US)
3	**Payback time**		

Recommendations
To arrange return circulation of air compressors cooling water

Description
To create return circulation it is necessary to install a pump, a cooling tower and a system of pipelines

Anticipated saving
At current water rates the saving of 6,703 m^3 of water is equivalent to 38,000 Rb (6,230 $US)

Necessary investments
Approximate cost of necessary equipment is 25,000 Rb

Payback time
Payback time is 9 months Project scale does not make necessary to estimate the internal rate of return

Terms
The Project can be implemented immediately

Technical risks related to variability of quality and amount of commercial products
No data on this type of risks is available

Initial data and calculations
Currently air compressors with water cooling are operated about 36 hours a day Cooling water consumption is 0 5 m^3/h Arrangement of a return circulation of air compressors cooling water will result in annual saving of 6,307 m^3 of water (Э = 0 5 m^3/h x 36 h/day × 365 days/year = 6,307 m^3)
At current water rates the saving of 11,316 m^3 of water with regard to expenditures on water consumption and discharge is 38,000 Rb (6,467 $US) The amount of make-up water is assumed to be 4%

Project No 6

Installation of accumulating tank for hot water supply system

1 **Savings**

Annual gas savings	237 thou m^3,	69,560 Rb (11,403 $US)
Annual water savings	306 6 m^3	1,840 Rb (301 $US)
Total savings		71,400 Rb (11,704 $US)

2 **Expenditures (including VAT)**

Accumulating tank installation	30,000 (4 900 $US)
Total expenditures	30,000 (4 900 $US)

3 **Payback time**

Recommendations
Installation of accumulating tank for hot water supply system

Description
To install accumulating tank for hot water supply system purposed to more efficient utilization of heat of steam-condensate mix from hot water boiler

Anticipated saving
At current gas rates the installation of an accumulating tank will result in saving of 237 thou m^3 of natural gas that is equivalent to 69,560 Rb (11,403 $US) Water saving will comprise 1,849 Rb (301 $US) Total saving will be 71,400 Rb (11,704 $US)

Necessary investments
Approximate cost of accumulating tank installation is about 30,000 Rb

Payback time
Payback time is 5 months

Terms
The Project can be implemented immediately

Technical risks related to variability of quality and amount of commercial products
No data on this type of risks is available

Initial data and calculations
Daily hot water consumption and temperature, as well as steam-condensate mix temperature are used as initial data
Heat losses of steam-condensate mix resulting from the lack of consumption of hot water (3-4 hours a day) and from repair works performed during heating period (4 hours a week) as follows

$$Q = (h1-h2) \times G \times t = 420\ 5\ GCal/year$$

Where

h1 is an enthalpy of steam-condensate mix to the boiler of hot water supply system (454 kCal/kg),
h1 is an enthalpy of condensate from the boiler of hot water supply system (80 kCal/kg),

G is condensate flow rate through the boiler (800 kg/h),
t is total time of zero water consumption of hot water (3 5 × 365 × + 32 × 4 = 1405 5 h/year)

Heat saving during the period of hot water consumption is equivalent to saving of 53,428 m^3 of natural gas per year
Besides, losses of evaporation steam and straightway steam from a condensate one are about 240 kg/h, while condensate losses are 306 6 m^3/year
In the case of installation of accumulating tank, even without automatic water temperature control under condition of relatively stable heat agent consumption will permit to maintain hot water temperature at necessary level without considerable steam overconsumption that currently is an often phenomenon (refer to Project No)
Gas saving will comprise 183 6 thou m^3

Project No 7

Reduction of air suction to boilers

1	**Savings**		
	Annual gas savings	227 6 thou m^3,	66,800 Rb (10,951 $US)
	Total savings		66,800 Rb (10,951 $US)
2	**Expenditures (including VAT)**		
	Repair and restoration work		30,000 Rb (4,918 $US)
	Total expenditures		30,000 Rb (4,918 $US)
3	**Payback time**		

Recommendations
To reduce air suction on stack gas stream

Description
Improvement of boilers' pressurization by sealing of hatches, cracks elimination, repair of boiler lining and mortar It is recommended to carry out the repair of Boiler No 1 first

Anticipated saving
At current gas rates the saving of 227 6 thou m^3 of natural gas is equivalent to 66,800 Rb (10,951 $US)

Necessary investments
As of the total cost of boiler overhaul the estimated cost of the repair work for two boilers is about 30,000 Rb including VAT

Payback time
Payback time is 6 months Project scale does not make necessary it to estimate the internal rate of return

Terms
The Project can be implemented immediately within the period of annual repair

Technical risks related to variability of quality and amount of commercial products
No data on this type of risks is available

Initial data and calculations
Inspection of Boilers 1 and 2 revealed air suction comprising 150% and 300% resulting in the increase of heat losses with stack gas Reduction of air suction to a level complying with process cards for boilers will result in boilers' efficiency increase by 2 3% and 6%, respectively Total saving will achieve 227 6 thou m^3 of natural gas that is equivalent to 66,800 Rb (10,951 $US)

Project No 8

Feed pump replacement

1 **Savings**

Annual electric power savings	131 4 thou kW*h,	34,650 Rb (5,680 $US)
Total savings		34,650 Rb (5,680 $US)

2 **Expenditures (including VAT)**

Pump unit	30,500 Rb (5,000 $US)
Total expenditures	30,500 Rb (5,000 $US)

3 **Payback time**

Recommendations
To replace feed pump in a boiler house

Description
To reduce consumption of boiler feed water in a circulation loop one of TsNSG-38-198 pumps is supposed to be replaced with a pump of 22 m^3/h nominal capacity, while the second pump will be left as a stand-by The replaced pump can be used at other location

Anticipated saving
At current gas rates the saving of 131,400 kW*h of electric power is equivalent to 34,650 Rb (5,680 $US)

Necessary investments
The pump with drive motor costs 30,500 Rb (5,000 $US) including VAT

Payback time
Payback time is 11 months Project scale does not make it necessary to estimate the internal rate of return

Terms
The Project can be implemented immediately

Technical risks related to variability of quality and amount of commercial products
No data on this type of risks is available

Initial data and calculations
Replacement of the pump with another of lower capacity will result to decrease of electric power consumption by 131,400 kW*h a year that comprises 34,650 Rb (5,680 $US) at current rates

Project No 9

Utilization of de-aerator evaporation heat

1	**Savings**		
	Annual gas savings	424,843 m^3,	124,400 Rb (20,400 $US)
	Total savings		124,400 Rb (20,400 $US)
2	**Expenditures**		
	Installation of two air heaters		40,000 Rb (6,500 $US)
	Total expenditures		40,000 Rb (6,500 $US)
3	**Payback time**		

Recommendations
Utilization of de-aerator evaporation heat for heating of combustion air

Description
Currently de-aerator evaporation heat is not utilized that results in direct steam heat losses to the environment It is recommended to install a combustion air heater utilizing de-aerator heat

Anticipated saving
At current gas rates utilization of de-aerator heat will result in the saving of 424,843 m^3 of natural gas that is equivalent to 124,400 Rb (20,400 $US)

Necessary investments
Capital investments related to installation of a unit for utilization of de-aerator evaporation heat comprise 40,000 Rb

Payback time
Payback time is 4 months

Terms
The Project can be implemented immediately

Technical risks related to variability of quality and amount of commercial products
No data on this type of risks is available

Initial data and calculations
Currently steam discharge from de-aerator to atmosphere at 1 2 atm is performed through a ∅50 mm pipe Steam losses estimated according to a reference chart is 800 kg/h or 0 45 GCal/h Utilization of de-aerator heat for heating of inlet combustion air will result in annual saving of 424,843 m^3 of gas

Project No 10

Repeated utilization of water from process units

1	**Savings**		
	Annual water savings	70 thou m^3,	420,000 Rb (68,600 $US)
	Total savings		420,000 Rb (68,600 $US)
2	**Expenditures**		
	Total expenditures		76,000 Rb (12,459 $US)
3	**Payback time**		

Recommendations
Repeated utilization of water from process units to a boiling house

Description
Repeated utilization of water from process units will result in elimination of municipal water consumption for a boiling house in the amount 70 thou m^3

Anticipated saving
At current water rates the saving of 70 thou m^3 of water is equivalent to 420,000 Rb (68,600 $US)

Necessary investments
Capital investments to the Project are related to a pipeline construction, probable installation of low capacity pumps and of indicator-detector of water contamination (dairy goods, butter, etc) are estimated in amount of 76,000 Rb (12,459 $US)

Payback time
Payback time is 3 months

Terms
The Project can be implemented immediately

Technical risks related to variability of quality and amount of commercial products
No data on this type of risks is available

Initial data and calculations
According to the plant water balance report boiling house consumes about 70 thou m^3 of water a year (8 m^3/h) Repeated utilization of water from process units (pasteurization units) will eliminate a necessity to use municipal water for the boiling house Cash saving will comprise

$$Э = 70{,}000 \times 3\ 96 + 0\ 88 \times 70{,}000 \times 2\ 32 = 420{,}000 \text{ Rb } (68{,}600 \text{ \$US })$$

Project No 11

Substitution of Ku-2-8 cationite for sulfuric carbon

1 **Savings**

Annual water savings	12,282 5 m^3	Rbl 48,638 7 ($7,974)
Cuts in discharge payments	10,809 m^3	Rbl 25,120 2 ($4,118)
Saving on salt	366 t	Rbl 84,180 ($13,800)
Aggregate savings		Rbl 157,938 ($25,892)

2 **Costs**

Ku-2-8 cationite (VAT inclusive)	Rbl 136,200 ($22,328)
Total costs	Rbl 136,200 ($22,328)

3 **Simple payback time**

Recommendations
Substitution of Ku-2-8 cationite for sulfuric carbon

Description
Substitution of Ku-2-8 cationite for sulfuric carbon would decrease regeneration frequency which would yield savings from lower water and salt consumption

Anticipated saving
With the current rates of water consumption and drainage and salt price, the annual saving in the terms of cash would be Rbl 161,363 2 ($26,453)

Investments required
The estimated cost of initial capital for this project would be some Rbl 136,200 (VAT inclusive) The figure is obtained from the information supplied by the cationite supplier

Playback time
The simple payback time would be 11 months The scope of the project does not need an estimate of the internal rate of return

Timing
The project may be realized immediately

Technical risks related to variability of quality and amount of commercial products
No data on this type of risks is available

Initial data and calculations
As initial data, the results of estimates of annual water consumption for regeneration and salt as well as the cost of sulfuric carbon and cationite

Resource (materials)	Cost unit	Annual discharge if used	
		sulfuric carbon	Ku-2-8 cationite
salt	230 Rbl/t	469 t	103 t
water used	3 96 Rbl/m^3	19,055 m^3	6,772 5 m^3
water drained	2 324 Rbl/m^3	19,055 m^3	6,772 5 m^3

At present, annual consumption of sulfuric carbon makes 10% of a filling (some 1 3 t) while using cationite in the first year, a full filling is required (8 t) With the price of cationite of 15,000 Rbl per

ton and of sulfuric carbon of 5,000 Rbl per ton, initial costs less inevitable costs of adding sulfuric carbon would make

$$C = 8 \times 15{,}000 \times 1\ 2 - 1\ 3 \times 5{,}000 \times 1\ 2 = \text{Rbl } 136{,}200$$

With these costs, a simple payback time would be 11 months

Project No 12

Switching of heating system from steam to water

1	**Savings**		
	Annual gas savings	385,649 m^3,	113,188 Rb (18,555 $US)
	Total savings		113,188 Rb (18,555 $US)
2	**Expenditures**		
	Total expenditures		200,000 Rb (32,780 $US)
3	**Payback time**		

Recommendations
Switching of the rest of the heating system from steam to water

Description
Currently about 30% of the heating system utilize steam The entire transfer to water heating will result in elimination of condensate losses and in higher efficiency of heat utilization The additional advantage of this project is the improvement of sanitary-hygienic conditions of work

Anticipated saving
At current gas rates utilization of de-aerator heat will result in the saving of 385,649 m^3 of natural gas that is equivalent to 113,188 Rb (18,555 $US)

Necessary investments
Approximate cost of the equipment is about 200,000 Rb

Payback time
Payback time is 1 year and 10 months

Terms
The Project can be implemented within summer period

Technical risks related to variability of quality and amount of commercial products
No data on this type of risks is available

Initial data and calculations
The flow measurements, as well as analysis of the balance of steam production and consumption at the plant revealed the following At condensate losses in "dead-end" of a steam heating system comprising 600 kg/h and more effective steam heat transfer in the course of its injection into water of a system, heat saving (after switching of the rest of the heating system from steam to water) will be about 1 t/h or 3,035 2 GCal a year (385,649 m^3 of natural gas or 113,188 Rb)

APPENDIX I OUTPUT OF THE OAO "PERMMOLOKO" BY MAIN PRODUCT TYPES IN 1997

No	Product	Unit	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Per year
1	Milk	t	1,005	919	1,015	885	891	891	898	997	963	1,034	1,030	987	11,515
2	Dietary foods	t	540	555	689	565	589	664	663	569	483	515	530	545	6,907
3	Cream	t	9 2	10 5	11 4	7 8	7 4	7 9	7 9	6 6	6 7	5 9	6 5	5 9	93 7
4	Sour cream	t	192	174	200	179	184	215	285	276	258	226	194	197	2,580
5	Cream cheese	t	86	100	91	83	82	86	75	72	75	74	79	76	979
6	Junket	t	53	55	54	50	45	47	46	43	47	53	58	53	604
7	"Tanzherko" beverage	t	61	45	70	63	55	46	51	30	15	23	27	33	519
8	Spread cheese	t	58	45	23	31	39	29	45	29	43	41	40	35	458
TOTAL		t*	3,048	2,820	3,271	2,900	2,928	3,229	3,526	3,330	3,145	3,023	2,862	2,871	36,953

* The output of commercial products is shown in terms of tons of whole milk

APPENDIX II CONSUMPTION OF FUEL AND POWER RESOURCES BY THE OAO "PERMMOLOKO" IN 1997

No	Power resource	Unit	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	P year
1	**Natural gas**	tfe	877	734	728	292	461	363	343	326	368	485	697	821	6,495
		000 m^3	763	639	634	254	401	316	299	284	320	422	607	715	5 654
	Rate	Rbl/m^3	0 2892	0 2841	0 2841	0 2841	0 2841	0 2841	0 2841	0 2841	0 2841	0 2841	0 2841	0 2935	
	Payment for 1997	**Rbl**	**220,660**	**181,540**	**180,119**	**72,161**	**113,924**	**89,776**	**84,946**	**80,684**	**90,912**	**119,890**	**172,449**	**209,853**	**1,616,914**
2	**Electric power**														
	Declared capacity	KW	729	807	741	779	754	909	880	1 068	1 039	817	844	817	
	Rate	Rbl/kW	66	66	66	66	66	66	66	66	66	66	66	66	
	Payment for 1997	Rbl	48 114	53 262	48 906	51 414	49 764	59 994	58 080	70 488	68 574	53 922	55 704	53 922	67,2144
	Electric power	MWh	460 90	423 00	610 10	384 70	531 40	651 40	562 00	707 20	643 80	581 90	364 60	453 60	6 374 6
	Rate	Rbl/kWh	0 192	0 192	0 192	0 192	0 192	0 192	0 192	0 192	0 192	0 192	0 192	0 192	
	Payment for 1997	Rbl	88 493	81 216	117 139	73 862	102 029	125 069	107 904	135 782	123 610	111 725	70 003	87 091	1,223,923
	Reactive power	kVAh	0	0	196 529	0	0	298 176	0	0	63 941	0	0	818 700	1 377 347
	Rate	Rbl/kVAh	0 017	0 017	0 017	0 017	0 017	0 017	0 017	0 017	0 017	0 017	0 017	0 017	
	Payment for 1997	Rbl	0	0	3 341	0	0	5 069	0	0	1,087	0	0	13,951	23,448
	Total	**Rbl**	**136,607**	**134,478**	**169,386**	**125,276**	**151,793**	**190,132**	**165,984**	**206,270**	**193,271**	**165,647**	**125,707**	**154,964**	1 919 515
3	**Municipal water**														
	Consumption	m^3	32 683	32 590	32 211	35 059	46 810	44 977	44 960	54 998	49 335	41 560	34 400	41 765	491,348
	Rate	Rbl/m^3	3 96	3 96	3 96	3 96	3 96	0 96	3 96	3 96	3 96	3 96	3 96	3 96	3 96
	Payment for 1997	Rbl	129 425	129 056	127 556	138 834	185 368	178 109	178 042	217,792	195 367	164 578	136,224	165 389	1,945,738
	Drainage	m^3	28,761	28 679	28 346	30 852	41 193	39 580	39 565	48 398	43 415	36 573	30 272	36 753	432 387
	Rate	Rbl/m^3	2 324	2 324	2 324	2 324	2 324	2 324	2 324	2 324	2 324	3 324	2 324	2 324	2 324
	Payment for 1997	Rbl	66 841	66 650	65 876	71 700	95 733	91 984	91 949	112,477	100,896	84 996	70,352	85,414	1,004,867
	Total	**Rbl**	**196,265**	**195,706**	**193,432**	**210,534**	**281,100**	**270,093**	**269,991**	**330,269**	**296,263**	**249,573**	**206,576**	**250,803**	**2,950,605**

APPENDIX III PRODUCTION OF FUEL AND POWER RESOURCES BY THE OAO "PERMMOLOKO" IN 1997

No	Power resource	Unit	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	P Year
1	**Heat power**	GCal	5 481 0	4,587 0	4 550 0	1 825 0	2 842 0	2,269 0	2 144 0	2 010 0	2 269 0	2,990 0	4 356 0	5,131 0	40,454 0
	Supply of the heat to outsider customers including	GCal	2,050	1 968 0	2,109 1	1 621 0	821 0	820 0	585 0	420 0	264 0	780 7	1 609 2	1,834 4	14 882 6
	Residential buildings	GCal	2 036	1 955	2 094 7	1 621 0	821 0	820 0	585 0	420 0	264 0	777 0	1 595 3	1 820 0	14 809 0
	Car repair station	GCal	14 30	12 96	14 4	0 0	0 0	0 0	0 0	0 0	0 0	3 7	13 9	14 4	73 6
	In the enterprise	GCal	3 431	2,619	2 441	204	2 021	1 449	1 559	1,590	2 005	2 209	2 747	3,297	25 571
2	**Cold**	GCal	319 95	239 90	365 24	391 90	471 45	790 80	745 35	840 65	712 50	560 35	357 95	381 70	6 177 74

APPENDIX IV. CONSUMPTION OF FUEL AND POWER RESOURCES BY THE OAO "PERMMOLOKO"

Figure IV-1 Power consumption by the boiler plant

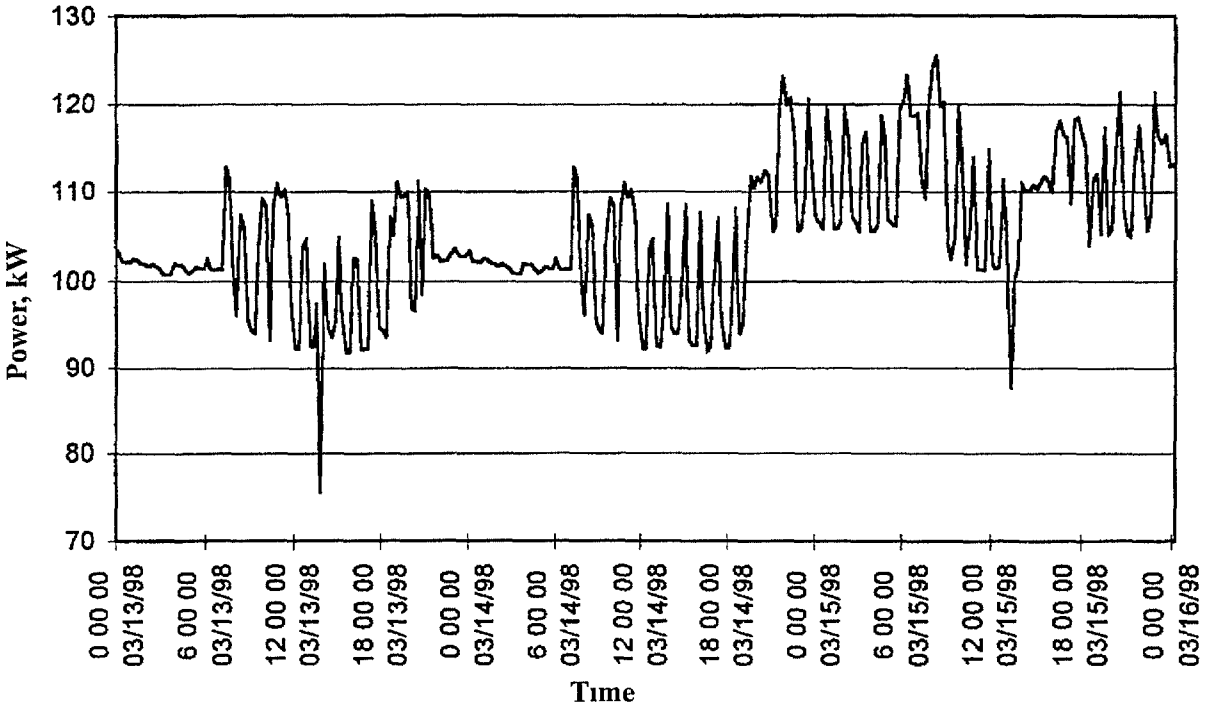


Figure IV-2 Power consumption by the ammonia compressor plant

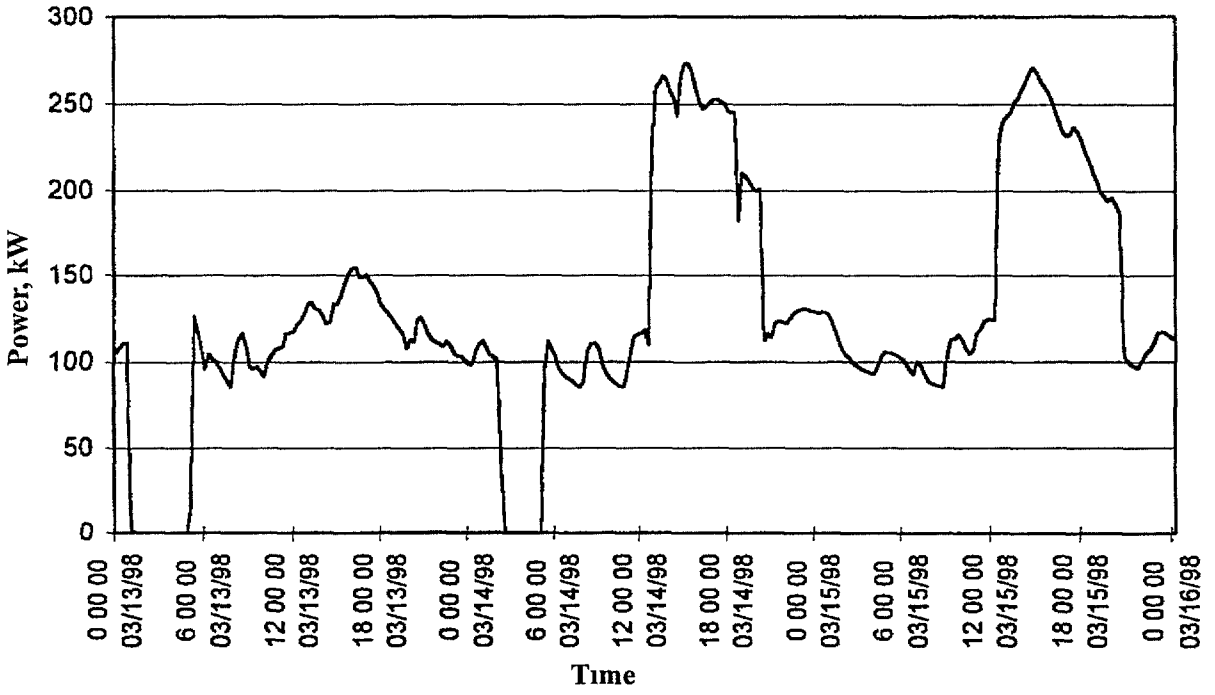


Figure IV-3 Power consumption by the air compressor plant

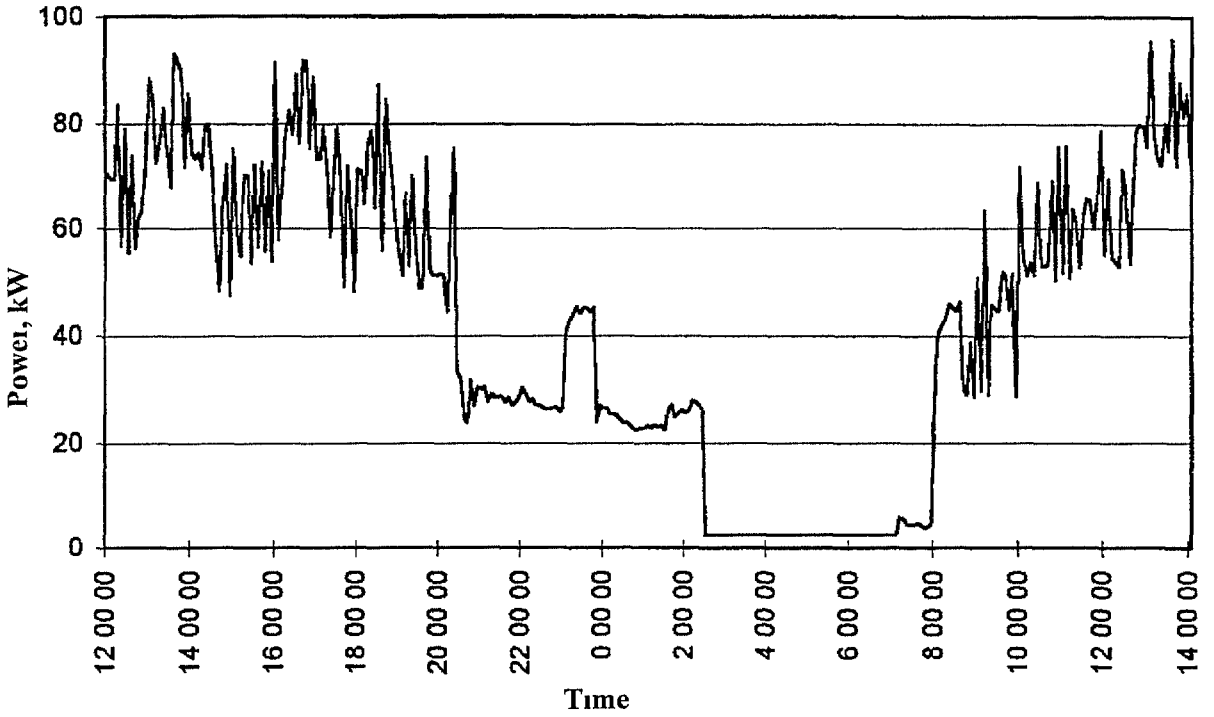
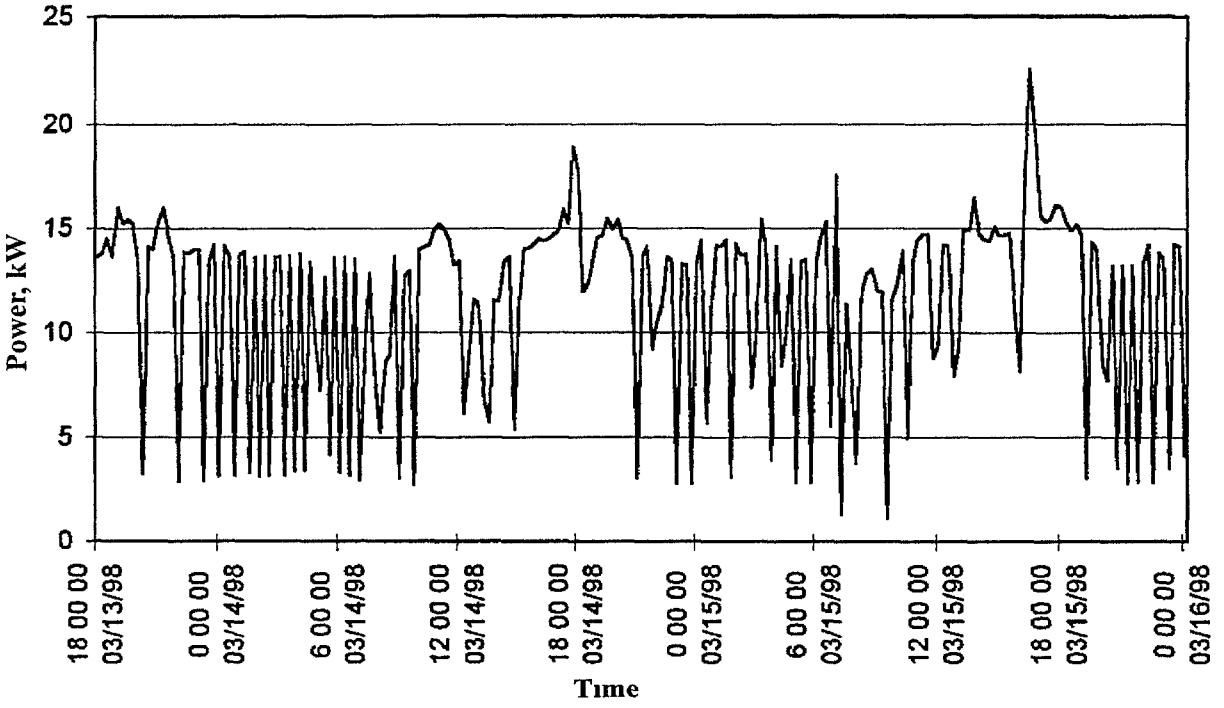


Figure IV-4 Power consumption by the sewage pump house



APPENDIX V. BOILERS TESTS

Boiler No 2 test results of March 12, 1998

Variable	Unit	Test No						
		1	2	3	4	5	6	7*
Test date		Mar 11	Mar 12	Mar 12	Mar 12	Mar 12	Mar 12	Mar 12
Test time	hh mm	16 00	14 00	14 30	15 00	15 30	16 00	16 15
Steam output, by instrument	t/h	8 25	7 7					
Steam pressure	kGs/cm^2	7 5	7 5					
Boiler burners								
Gas pressure at 1st burner	Pa	100	50	50	50	50	50	50
Gas pressure at 2nd burner	Pa	100	50	50	50	50	50	50
Air pressure at 1st burner	Pa	200	100	100	100	100	30	30
Air pressure at 2nd burner	Pa	200	200	100	50	15	50	50
Boiler vacuum	mm WC	2	2	2	2	2	2	2
Boiler outgoing gases								
Temperature	°C	238	236	234	233	230	229	232
Oxygen, O_2	%	10 3	11 6	11 5	11 2	10 7	10 5	10 3
CO_2	%	5 9	5 2	5 3	5 4	5 7	5 8	5 9
Air excess	%	90	114	111	105	95	92	90
NO_x	ppm	43	36	36	38	40	42	42
CO	ppm	1	4	4	4	4	4	4
Losses with CO underburned	Mcal/h	0	0	0	0	0	0	0
Losses with CO underburned	%	0	0	0	0	0	0	0
Boiler efficiency, by instrument	%	86 3	84 5	85	85 5	86 5	86 9	87
Feeding water								
T° upstream of the economizer	°C	102						
T° downstream of the economizer	°C	128						
Outgoing gases d/s of the economizer								
Temperature	°C	80						
Oxygen, O_2	%	16 3						
CO_2	%	—						
Air excess	%	350						
Heat losses with outgoing gases	%	12 0						
NO_x	ppm	17						
CO	ppm	1						
Losses with CO underburned	Mcal/h	0						
Losses with CO underburned	%	0						
Losses to the environment	%	4						
Boiler efficiency d/s of economizer	%	84						

* The test was done after all outer visible slits (man-holes and cracks) have been closed

Boiler No 1 test results of March 13, 1998

Variable	Unit	Test No						
		1	2					
Test date		Mar 13	Mar 13					
Test time	hh mm	14 30	15 00					
Steam output, by instrument	t/h	5 2						
Steam pressure	kGs/cm^2	7 2						
Boiler burners								
Gas pressure at 1st burner	Pa	60	19					
Gas pressure at 2nd burner	Pa	60	19					
Air pressure at 1st burner	Pa	15	15					
Air pressure at 2nd burner	Pa	17	13					
Boiler vacuum	mm WC	2	2					
Boiler outgoing gases								
Temperature	°C	227	224					
Oxygen, O_2	%	14 0	11 6					
CO_2	%	3 7	5 2					
Air excess	%	193	116					
NO_x	ppm	18	41					
CO	ppm	9	2					
Losses with CO underburned	Mcal/h	0	0					
Losses with CO underburned	%	0	0					
Boiler efficiency, by instrument	%	79 6	92 2					
Feeding water								
T° upstream of the economizer	°C							
T° downstream of the economizer	°C							
Outgoing gases d/s of economizer								
Temperature	°C	103						
Oxygen, O_2	%	14 0						
CO_2	%	3 7						
Air excess	%	193						
Heat losses with outgoing gases	%	7 65						
NO_x	ppm	17						
CO	ppm	9						
Losses with CO underburned	Mcal/h	0						
Losses with CO underburned	%	0						
Losses to the environment	%	5						
Boiler efficiency d/s of economizer	%	92 3						

* The test was done after all outer visible slits (man-holes and cracks) have been closed

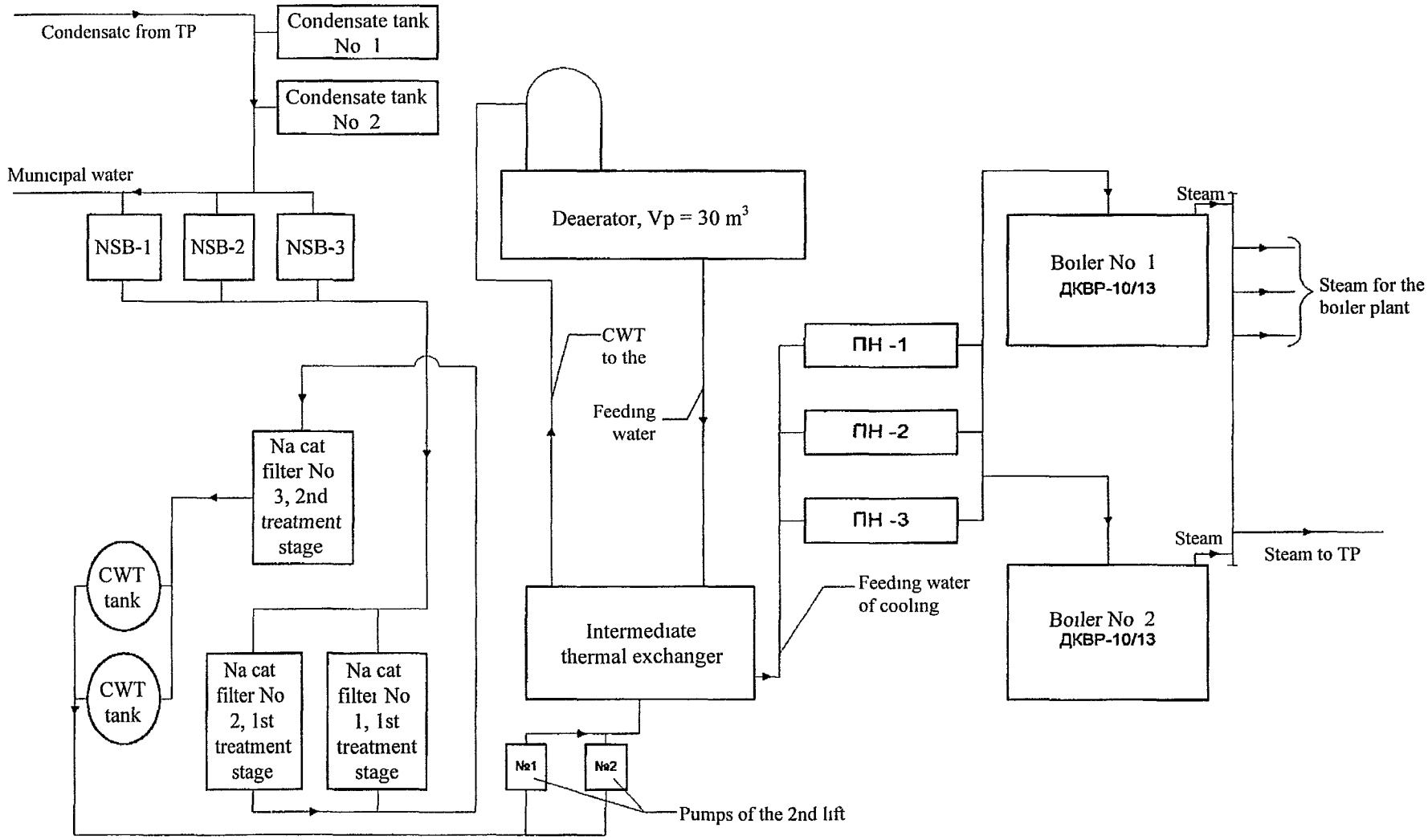
APPENDIX VI HEAT LOSSES THROUGH THE NON-INSULATED SEGMENTS OF BOILING HOUSE PIPELINES

No	Pipeline segment length, m	Pipe diameter, m	Surface temperature, °C	Heat losses, kW
Boiling house				
1	56	0 027	120	7 2
2	12	0 036	120	1 8
3	65	0 042	120	9 9
4	28	0 053	80	3 64
5	73	0 060	130	11 24
6	68	0 080	80	12 92
7	20	0 089	160	11 4
8	4	0 180	80	2 1
Total for boiling house				**60 2**
Boiler				
1	14	0 042	80	0 95
2	43	0 060	70	5 31
3	16	0 060	100	3 58
4	48	0 076	70	7 3
5	42	0 089	70	7 33
Total for boiler				**24 47**
Total				**84 67**

ENCLOSURE VII. LOCATION OF DRL LAMS IN THE ENTERPRISE WORKSHOPS

No	Enterprise unit	No of lamps installed, pcs	
		DRL-250	DRL-400
1	Tare workshop	28	3
2	Sour cream and cream cheese workshop	16	—
3	Filling workshop	20	—
4	Ice workshop	5	—
5	Acceptance equipment workshop	6	1
6	Cheese workshop	22	3
7	Installation workshop	4	—
8	Compressor plant	11	—
9	Garage	3	—
10	Refrigerator	4	3
11	Boiler house	—	10
12	Outdoor store lighting	7	—
13	Marketing	4	22
14	Parking	10	—
TOTAL		137	42

APPENDIX VIII LAYOUT OF THE BOILER PLANT



APPENDIX IX. ESTIMATION OF FUEL SAVING THROUGH UTILIZATION OF AMMONIA VAPOR HEAT

Actual refrigeration capacity of ammonia compressor station in 1997 comprised 6,177 4 GCal The following parameters were considered while estimating minimum heat removal 7 5 atm discharge pressure, 1 5 atm suction pressure

Cycle point	Temperature, °C	Pressure, atm	Enthalpy, kCal/kg
Suction to compressor	15	1 5	417
Discharge line	110	7 5	462
Saturated steam	17	7 5	405
Outlet from condenser	17	7 5	120
Inlet to evaporator	-25	1 5	120

Maximum heat that theoretically can be utilized is vapor heat q = 462 - 405 = 57 kCal/kg

At certain yearly refrigeration capacity of the system it is possible to calculate annual cooler consumption Specific refrigeration capacity of the cycle is q = 417 - 120 = 297 kCal/kg

Yearly cooler consumption can be calculated as follows

$$G = Q/q = 6,177,400,000/297 = 20,799\ 3\ t$$

To calculate the amount of water a number of assumptions are necessary Assume, that cold water temperature is 12°C

$$Q = 20,799,300*57 = 1,185\ 6\ \text{GCal that is the heat of vapor cooling}$$

Assume water temperature from the heat exchanger to be 70°C, then water amount is the following

$$G = 1,185,600,000/(70 - 12) = 20\ 44\ \text{thou t per year or 56 t/day}$$

At 95% heat exchanger efficiency vapor heat will be 1,126 3 GCal that will make it possible to prepare 19,491 t of water per year or 53 t/day

Production of such amount of heat in a boiling house will necessitate 143 1 m^3 of gas or in cash it will be 42,000 Rb (6,886 $US)

APPENDIX X VENTILATION EQUIPMENT LIST

No	Shop	Fan type	Q-ty	Air flow rate, m^3/h	Drive	
					Motor type	Horsepower, kW
Exhaust ventilation						
1	Compressor station	Ts4-70	1	18800	4A132M6	7,5
2	Canteen	Ts4-70	2	2600	4A80M2	1,5
3	Battery room	Ts4-70	1	11000	4A100l6Y2	4,0
4	Equipment room	KTs3-90	4	33200	4A100LB4	8,8
5	Lab	Ts4-70	1	3100	4A71A4	0,75
6	Packaging shop washing unit	Ts4-70	1	4000	4A80B4	1,5
7	Utility rooms	Ts4-70	1	5000	4A90LA4	2,2
8	Packaging shop	KTs3-90	6	33000	4A80A6	4,5
Intake ventilation						
1	Packaging shop	Ts4-70	1	16100	4A13296	5,5
2	Packaging shop	Ts4-70	1	17410	4A132M6	7,5
3	Spread cheese shop	TsP7-40	1	2400	A042-4	2,18
4	Spread cheese shop	BTs4-70	1	18300	A52-4	7,0
5	Cottage cheese ferment shop	Ts4-70	1	25300	A073-6	20,0
6	Battery room	Ts4-70	1	5600	A0-32-6	1,2
7	Unit area	Ts4-70	1	19700	K021-4k	15,0
8	Unit area	Ts4-70	1	23600	A02-72-4	30,0
9	Bottling shop	Ts4-70	1	9200	K021-4k	15,0
10	Mechanical shop	Ts4-70	1	5420	4AM112	5,5
11	Compressor shop	Ts4-70	1	17000	4A132S6	5,5
12	Packaging shop washing unit	Ts4-70	1	10000	4A112MA4	5,5
13	Canteen	TsP7-40	1	1810	AO42-4	2,2

No	Shop	Fan type	Number	Air flow rate, m^3/h	Drive	
					Motor type	Capacity, KW
Heat screens						
1	Packaging shop	Ts4-70	1	17000	AO2-52-6	7,5
2	Packaging shop	Ts4-70	1	21000	AO2-62-8	10,0
3	Receiving units	Ts4-70	3	2500	AOL2-11-6	0,4
4	Platform	Ts4-70	1	38000	AO2-71-6	17,0
5	Spread cheese shop	Ts4-70	1	3000	AOL2-12-4	0,8
6	Battery room	Ts4-70	1	8000	AO2-42-4	5,5