PN ACD-434

ENERGY AUDIT

PERMKHLEB STATE COMPANY

Perm Oblast
RUSSIA

Prepared for

US AGENCY FOR INTERNATIONAL DEVELOPMENT
Washington, D C 20253

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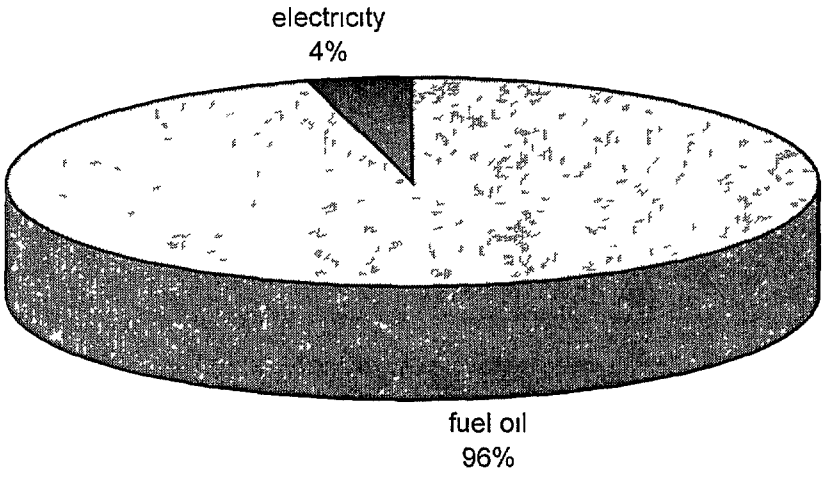
1 Executive Summary

This report presents the results of the energy audit carried out at the State Unitary Enterprise "Permkhleb State Company" in March- May 1998 The work was done in close contact with the management of the energy department and the operating personnel of the company Experts from the energy efficiency laboratory of AO Permenergo and the technical laboratory of the Gosenergonadzor enterprise made an important contribution to this work

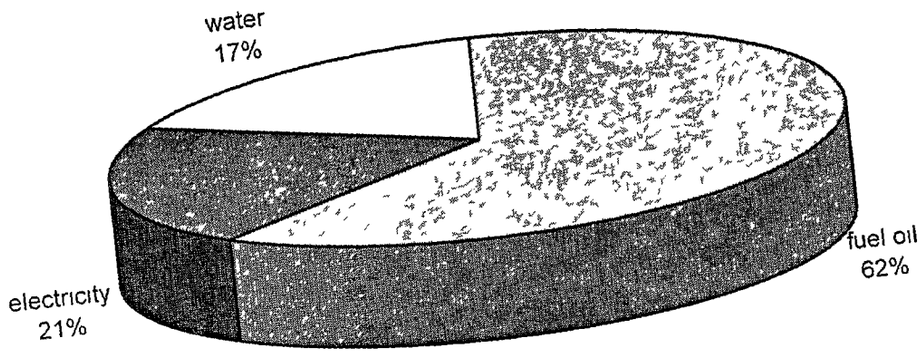
A graphic representation of the general structure of energy consumption by Permkhleb is given in Diagram 1 1, where the quantity of different energy resources consumed is expressed as the power equivalent The input data were the data on energy consumption in1997 The Diagram shows that the Permkhleb company uses just two types of energy resources fuel oil and electricity

Diagram 1 1 Energy Consumption Structure



Along with the energy consumption structure, it is very important to know the structure of payments for energy resources Diagram 1 2 shows Permkhleb's energy payment structure where fuel oil accounts for the majority of payments

Diagram 1 2 Structure of Payments for Energy Resources



Based on the results on the energy audit, the following energy efficiency measures can be recommended

Table 1 Energy Efficiency Measures

№	Description	Energy Savings		Project Costs Rubles	Payback period, months
		GJ	thousand rubles ($US)		
No-cost and low-cost					
	Insulation of the pipelines and the hot water tank	828 6	6,250 (1,025)	690 (113)	2
1	Insulation of electric ovens	619 2	52,116 (8,544)	1,540 (250)	1
2	Introduction of to time-of-use electricity rates	--	8,250 (1,352)	3,800 (622)	6
3	Reduction of heat losses in gas ovens	836 4	6,234 (1,020)	4,000 (656)	8
Middle-cost					
5	Rationalization of the hot water supply system	7,955 1	75,650 (12,400)	55,000 (9,000)	9
TOTAL		**10,239**	**148,500 (24,350)**	**65,030 (10,660)**	**6**

The numbers in the TOTAL row reflect the general effect of the implementation of all the measures

The proposed measures make it possible to decrease the total amount of energy consumed in 1997 by 18% and to reduce payments for energy resources and water by 15%

It must be mentioned that after the heat supply system is overhauled and the fuel-firing equipment changes over from fuel oil to gas, there will be a big cut in payments for energy resources and the ratio of energy and money saved through the proposed measures to the total amount of energy consumed will greatly increase, because these projects deal with those aspects of energy consumption which are not included in the overhaul plan

To sum up, the Permkhleb company has great potential for energy saving

2 Introduction

The energy audit was carried out by a group of engineers of the East-West Energy Agency in Moscow as part of the project "Energy Efficiency and Market Reform Project for Russia"(Contract # CCN-0020-C-00-152-00) The purpose of this project was to analyze the use of energy resources by the company and their cost, to identify places of inefficient use and to develop a set of energy-saving measures

During its visit to the company, the group obtained a great amount of information on the power and technological equipment, operating conditions of the equipment, the state of the power supply distribution systems, etc These data were systematized to be presented in this report

The data were collected by means of direct measurements, for example, capacities of power-consuming equipment, and also by means of calculations based on design plans and specifications and on information supplied by the operating personnel For direct measurements, up-to-date portable instruments of western manufacture were used The collected data were processed with the help of spreadsheets, which make data processing very fast and provide a graphic representation of results

3 Description of the Enterprise and the Technological Process

3 1 General Description of the Enterprise

The Permkhleb State Company is located in the city of Perm and is the city's third largest enterprise by annual output of bread and confectionery The enterprise was established in the 1980's as a result of the dissolution of the city bread-baking complex that had comprised 13 bakeries Until 1994, the new enterprise had consisted of two bakeries located in different areas In 1994 the equipment of one of the bakeries was dismantled and then installed in the shops of the bakery under survey, which had previously produced only round loaves of wheat and rye bread (2 ovens) and white loaves (1 oven) This fact explains the high concentration of main and auxiliary equipment in the bakery's building, which is too small for the existing volume of production The main premises have been used for bread baking since 1938 Before the amalgamation of the two bakeries, daily output did not exceed 5 tons of bread After the amalgamation, the capacity of the installed bread-baking equipment amounted to 29 tons of bread a day

The enterprise comprises the main premises including production shops (administrative services are located in another part of the city) and a chain of retail outlets

The types of products and monthly outputs in 1997 are given in Attachment 1

Table 3 1 1 demonstrates changes in annual output and payroll in 1994 – 1997

Table 3 1 1 General Data

№	Name	Unit of Measurement	1994	1995	1996	1997
1	Volume of services	million rubles	842	12761	23334	27152
2	Output of products, including Bread Confectionery	tons tons tons	5392 5212 180	6700 6594 106	8135 8062 73	9111 8923 188
3	Payroll	men	217	212	237	282

As the table shows, since 1994 output has been on the increase owing to the gradual installation of the equipment brought in from the other bakery

Table 3 1 2 demonstrates the product cost structure for 1997

Table 3 1 2 Product Cost Structure by Cost Element

№	Cost Elements	Share, %
1	**Material costs, including**	**54 4**
	Raw materials	47 1
	Fuel	2 6
	Electricity	1 3
	Water	3 4
	Labor costs	**10 1**
	Deductions for social needs	**2 1**
	Depreciation costs	**9 1**
	Other expenses, including	**24 3**
	Taxes	8 4
	Services from third parties	15 9
	TOTAL	**100**

3 2 Description of Production

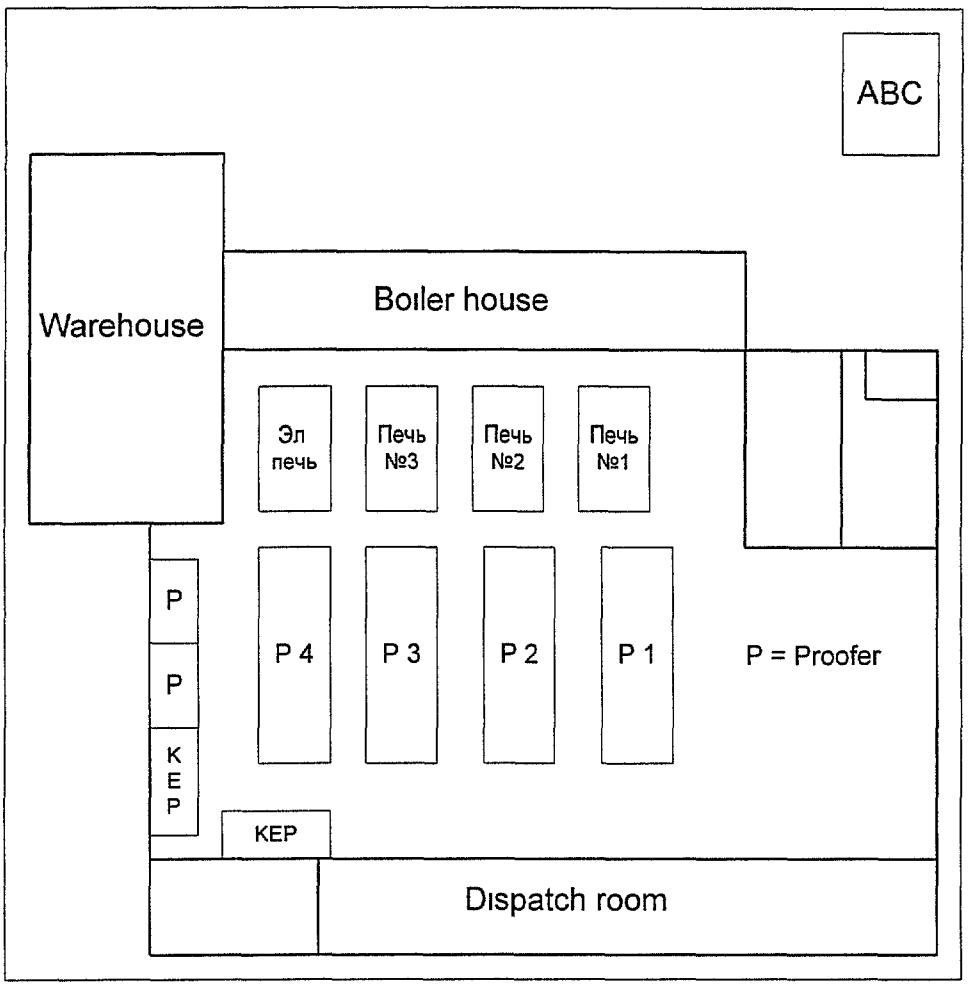
3 2 1 Description of the Enterprise's Shops

The enterprise has two main shops for bread baking and for confectionery production All of the production equipment is concentrated in a building that has 5,100 m^3 of space The building has an extension with a space of 1,620 m^3, where there is a storehouse for finished products and a canteen In the semi-basement (first floor) there is an oven room, a bakehouse, a storehouse and auxiliary rooms On the second floor there are a kneading room and a confectionery shop On the third floor there are flour silos which distribute flour to the flour meters in the kneading rooms In the attic there is a room with storage tanks for hot and cold water

On the grounds of the bakery there is a two-storeyed building (1,250 m^3) where the enterprise's auxiliary services are located a laundry, accounting department, etc

The chart of the bakery (Figure 3 2 1) shows the layout of the main energy-using equipment in the bakehouse

Figure 3 2 1 Chart of the Enterprise

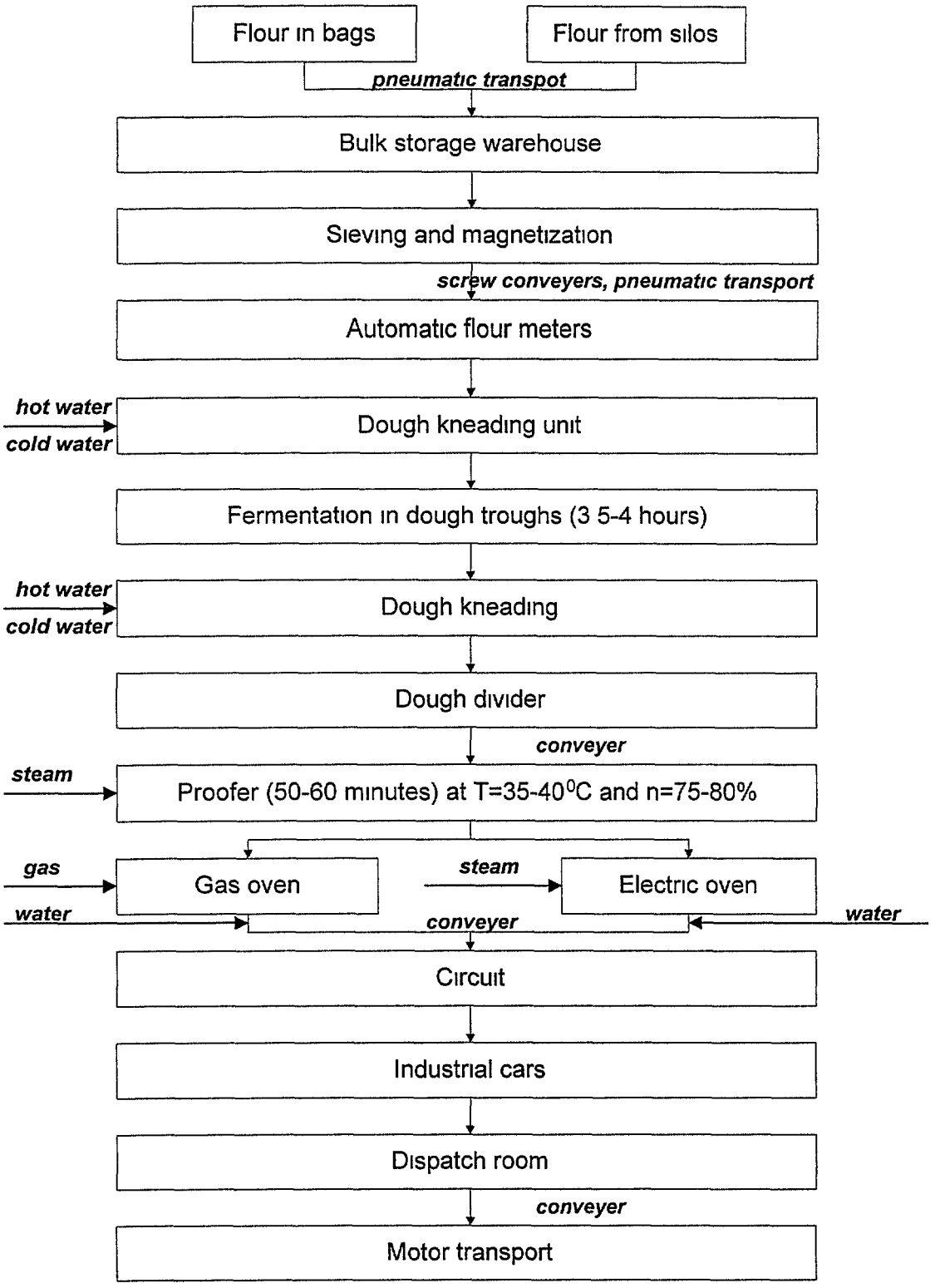


The bakehouse operates 24 hours a day, in two shifts, 12 hours each The first shift begins at 0800 hours
The confectionery shop operates in one shift from 0700 hours to 1900 hours At the time when the energy audit was conducted, the shop was under repair and therefore it operated at night from 1900 hours to 0700 hours

3 2 2 Description of the Technological Process

The bakery has two main technological lines bread baking and confectionery production
The basic materials for bread baking include flour of different grades, yeast and water Figure 3 2 1 represents the diagram of the bread-baking technological process showing the places where energy resources are used

Figure 3 2 1 Bread Baking



The main loads are the electric ovens in the bakehouse For production of rolls and buns, the enterprise uses two electric ovens KEP-600 with 38 4 kW of installed capacity of electric heaters The oven output is 0 9 tons a day After loading the oven, the operator at the control desk sets required temperature and baking time Temperature in the oven chamber is maintained automatically by switching on and off groups of electric heaters White loaves are baked in an electric oven HPA-10A Its output is 3 9 tons a day and its electric heaters have

112 5 kW of installed capacity Required temperatures in the oven are maintained automatically, too

For baking rolls and buns, steam is supplied into the electric oven's chambers Steam feed is controlled by the operator from the control desk The ovens operate 18–19 hours a day After a shutdown, about two hours are required to achieve the working temperature in the oven Before baking, dough stays in proofers at temperature of 40°C and humidity of 75-80% for 50-60 minutes These conditions are provided with the use of steam The bakery has 4 proofers, each with a capacity of 3 8 tons of day The required steam pressure in the proofers and the electric ovens is 0 4 atm

The bakery has three ovens of the FTL-2 type Previously, these ovens had fired fuel oil During the energy audit all the ovens were repowered to gas The ovens are equipped with automatic controls that ensure burning safety and adjust temperature in the baking chamber Automatic temperature control includes automatic lighting of the burner and control of gas consumption in the burner for maintaining the required temperature in the baking chamber

Automatic control of gas consumption in the burner is carried out in two modes "Small Flame" and "Big Flame"

The output of the electric oven FTL-2 is 16 5–18 5 tons a day The design gas consumption per oven is 38 8 nm^3/hour There is no steam supply to the oven chamber After baking, bread is moistened with water

The furnace chamber is heated up with smoke gases in a no-contact way through a brick wall The baking chamber is of the line-end type For ventilation it has an air duct with a slide valve Flue gases are drawn along the duct by the stack's natural draught The baking chamber is heated by hot flue gases coming along ducts in the brick wall through the radiator and above the steel ceiling Along the lateral and rear ducts gases move to the upper ducts for heating the baby boilers and then to the removal gas duct equipped with a draught gate The oven conveyer is set in motion by a drive, which consists of an electric motor, worm gear, V-belt transmission and a limit switch

When the ovens were repowered to gas, no modifications in the oven construction were planned The working temperature in the oven chamber is 180–185°C The complete run-up of the oven from the cold state takes 14-16 hours

Flue gases from all the ovens are collected in a common flue and then removed through a metal stack

During the energy audit the gas ovens operated in the following way

- oven 1 – 15 hours a day (idle time from 1500 hours to 2400 hours)
- oven 2 - 19–20 hours a day (idle time from 1300 hours to 1800 hours)
- oven 3 – 20 hours a day (idle time from 1500 hours to 1900 hours)

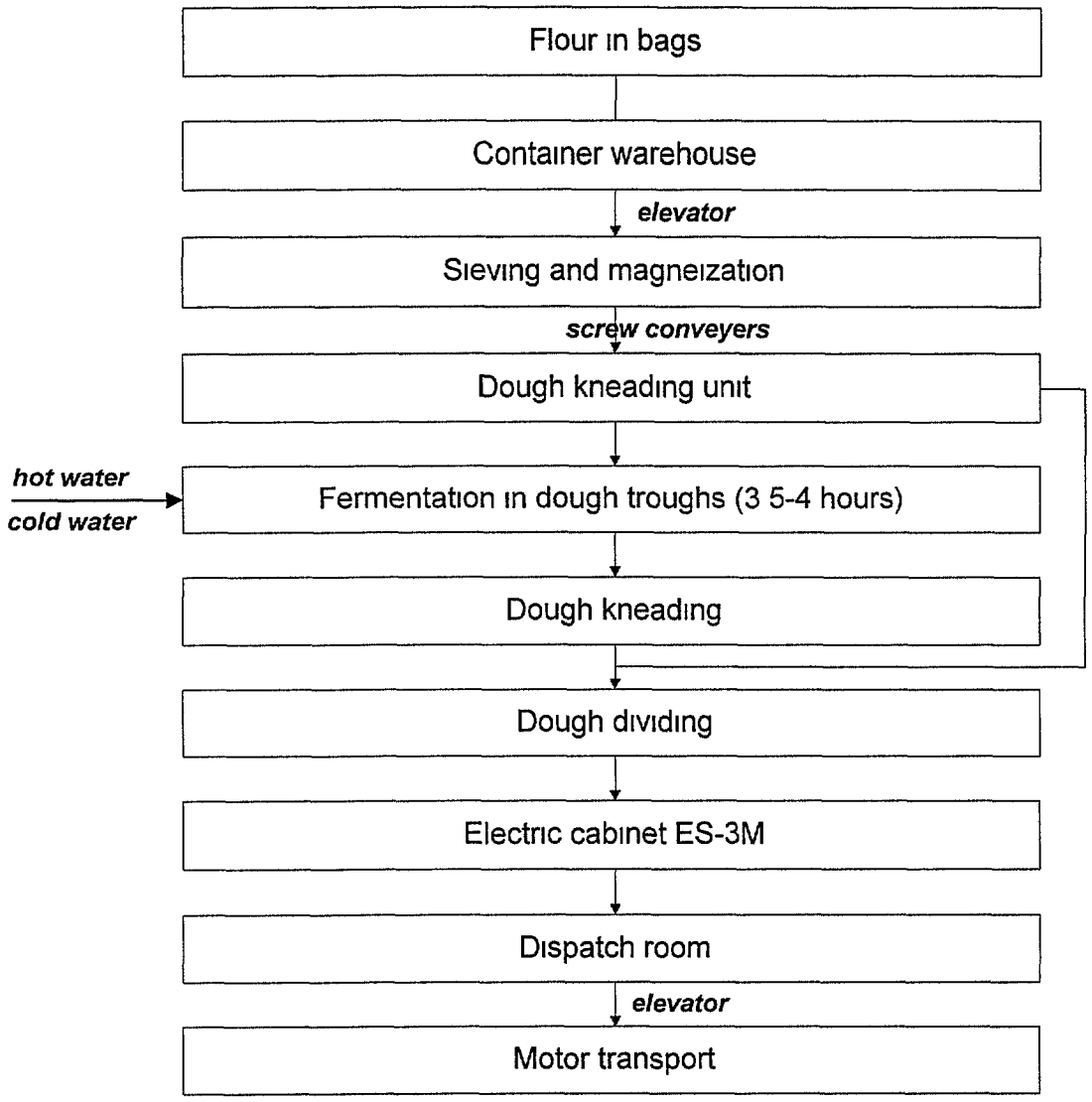
If idle time is less than 4 hours, the burners are put in the "small flame" mode, but in case of longer idle periods they are put out One or two hours before loading, the ovens are kindled During the first 4 hours of idle time the temperature in the chamber falls down very little and therefore the ovens are used for drying rusks and various types of prepared food

The ovens stay idle when there are no orders for buns and rolls

The bakery has a pneumatic transport system for transporting bulk flour to the flour storage, feeding flour into the sieving and magnetization units and then putting it into the automatic flour silos The pneumatic transport system includes three fans (one in reserve), each with a capacity of 11 kW and a rotational speed of 3000 revolutions per minute The operators switch on the fans when flour is filled into the bulk storage bins

The confectionery production technological scheme is shown in Figure 3 2 2

Figure 3 2 2 Confectionery Production



After kneading, dough for baba au rhum is fermented, whereas dough for other types of confectionery goes from the kneading machine to the dividing unit

Dough is divided manually Baking is done in electric cabinets In the confectionery shop there are 5 electric cabinets with a capacity of 19 5 kW each

4 Characteristics of Energy Consumption by the Enterprise

4 1 Description of Equipment and Operating Conditions of the Energy Using Systems

POWER SUPPLY SYSTEM

Power to the buildings on the main grounds of the bakery is supplied through two 0 4-kV service entrances from transformer substations TS-2002 and TS-2022 The old boiler house has a separate service entrance for power supply The power supply diagram is shown in Figure 4 1

The diagram shows the places where the energy loggers used for the energy audit were installed

Abbreviations used in the diagram EF – exhaust fan, FVF – forced ventilation fan, RC – refrigerant compressor, P – proofer, KM – kneading machine

The bakery does not have reactive power compensation units
For metering active and reactive power, at the inlet from TS-2002 there are electricity meters SA4U0I672M and SR4U-I673M and at the inlet from TS-2022 there is just one active power meter SA4U-I672M At the inlet of the old boiler house there is an active power meter SA4U-I672M There is no internal accounting of energy distribution by shop

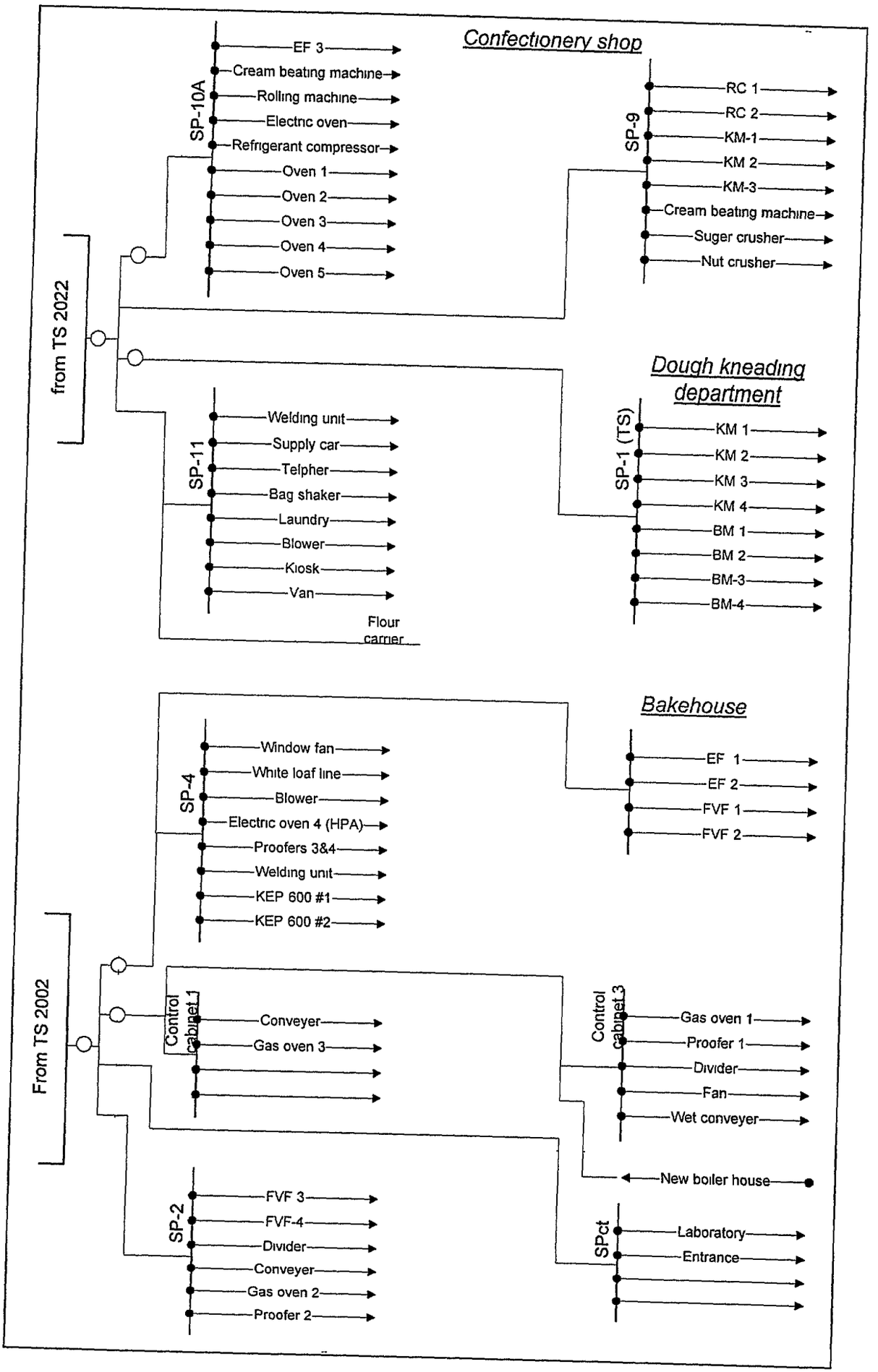
Lighting

The shops are lighted with different types of lamps Attachment IV gives a list of the lighting equipment indicating the capacity of the lamps and their placement in the shops

Ventilation system

The bakery has 11 ventilation fans The main ventilation load is in the bakehouse where two forced-ventilation fans and two exhaust fans, with a capacity of 5 5 kW each, operate 24 hours a day
The forced-ventilation fans in the bakehouse have steam air heaters (steam pressure – 0 4 atm) The rate of air flow through the heaters is about 29000 m^3/hour When the heat supply system is overhauled, the steam air heaters will be switched over to water

Figure 4 1 Power Supply Diagram


Confectionery shop
from TS 2022
SP-10A
EF 3
Cream beating machine
Rolling machine
Electric oven
Refrigerant compressor
Oven 1
Oven 2
Oven 3
Oven 4
Oven 5
SP-9
RC 1
RC 2
KM-1
KM 2
KM-3
Cream beating machine
Suger crusher
Nut crusher
Dough kneading department
SP-11
Welding unit
Supply car
Telpher
Bag shaker
Laundry
Blower
Kiosk
Van
Flour carrier
SP-1 (TS)
KM 1
KM 2
KM 3
KM 4
BM 1
BM 2
BM-3
BM-4
Bakehouse
From TS 2002
SP-4
Window fan
White loaf line
Blower
Electric oven 4 (HPA)
Proofers 3&4
Welding unit
KEP 600 #1
KEP 600 #2
EF 1
EF 2
FVF 1
FVF 2
Control cabinet 1
Conveyer
Gas oven 3
Control cabinet 3
Gas oven 1
Proofer 1
Divider
Fan
Wet conveyer
New boiler house
SP-2
FVF 3
FVF-4
Divider
Conveyer
Gas oven 2
Proofer 2
SPct
Laboratory
Entrance

15

REFRIGERATION SYSTEM

Refrigerators are needed for the storage of butter, margarine, yeast, eggs and other foodstuffs used in bread baking and confectionery production Different foodstuffs are kept in different refrigerators with different temperature The bakery has a stock of single-stage piston compressors (FAK-1 5) and compression-condensation (VS-800, VSe-800) units and machines (MBB-1-2) All the refrigerant units maintain temperature in refrigerating chambers automatically Table 3 2 2 provides a list of refrigerating units and their placement in the shops The compressors are air-cooled

Table 4 1 1 List of Refrigerant Equipment

№	Compressor Type	Department	Year of commissioning	No of units	Output, Gcal/h	Pressure kg(f)/cm^2	Drive capacity, kW	Operating conditions
1	MVV-1-1	warehouse	1997	1	6000	1	2,2	K
2	FAK-1,5	canteen	1980	1	1500	1	1,5	В,Л,О
3	FAK-1,5	warehouse	1980	1	1500	1	1,5	В,Л,О
4	FAK-1,5	warehouse	1985	1	1500	1	1,5	В,Л,О
5	VC-800	confectionery	1997	1	800	1	0,8	K
6	VCe-800	confectionery	1995	3	800	1	0,8	K
7	VCe-800	bakehouse	1995	1	800	1	0,8	K
8	AST-3,2	bakehouse	1980	1	650	1	0,63	K
9	VCe-800	retail outlet	1980	1	800	1	0,8	K

* D – 24 hours a day, Sp - spring, S - summer, A - autumn

Heat Supply System Heating, Ventilation and Hot Water Supply

The energy audit was conducted during the overhaul of the entire heat supply system Until 1998, heat had been supplied from the old boiler house located in another area The boiler house produced steam for heating, preparation of hot water, technological needs and for heating up fuel oil for the ovens in four 0 5-m^3 tanks

The old boiler house fires fuel oil There is no condensate return from the main territory to the boiler house Condensate was partly discharged into the sewerage system and partly used for heating some auxiliary premises (the dispatch room, the fitters' room, the guards' room, etc), after which it was also discharged into the sewerage system

In 1998 the bakery built a new boiler house located in the extension of the production block and equipped with three steam boilers, a water preparation set VPU–2 5, a gas control unit and a 6-m^3 tank of chemically cleaned water The total design capacity of the new boiler house is 1308 Gcal/hour Due to the shortage of funds the bakery installed two boilers that had been in use since 1984 Table 3 2 3 gives a description of the installed boilers

Table 3 2 3 Boilers

№ of Boiler	1	2	3
Type	E-1,0-0,9M3	E-1,0-0,9M3	E-1,0-9-1M
Year of manufacture	1984	1984	1997
Mode	steam	steam	steam
Steam state	saturated	saturated	saturated
Rated capacity, ton/hour	1	1	1
Working pressure, atm	6	6	6
Temperature of feedwater, °C	50	50	50
Design efficiency, %	88	88	88
Fuel rate, nm^3/час	93	93	93
Fuel	natural gas		

The boilers have burners of the G1 type that fire low-pressure gas A set of controls KCU-9, which is supplied together with the boilers, is used as the control unit The boilers are started by pressing the button "Start", after which all other start-up operations are performed automatically

Combustion products will be removed through the existing metal stack Economizers and heat exchangers are not installed

The gas control unit supplies gas to the boilers and the ovens The boiler house uses Siberian natural gas from the city gas main For gas consumption metering the gas control unit has a gas recorder of the SG type

Fuel oil is to be used as back-up fuel

Earlier the bakery used steam heating When the new boiler house is put in operation, heating water will prepared in a transonic spray atomizer, "Transsonic", designed and constructed by the Entur Company (the city of Izhevsk) Control of heat supply to the systems is of high quality The temperature of heating-system water is 70–95°C

Hot Water Supply System

Water for HWS is currently prepared in the following way In the attic of the main building there are two 4 5-m^3 tanks for cold and hot water The tanks are not insulated Cold tap water is fed into the hot water tank and heated with perforated steam The Bank is connected with a circuit consisting of 5 heat recovery baby boilers installed on the smoke flues of the gas ovens There is no automated control of temperature or of the tank's filling level When the tank is overfilled, the hot water is discharged through a by-pass pipeline into the sewerage system The tank's filling level is controlled manually by the shop operators who either slightly open or close the valve of the cold water pipe Steam supply to the hot water tank is continuous
The bakery's plan for the heat supply system overhaul does not provide for any significant modifications in the HWS system

Water Supply

Pressure in the city water-supply pipes in the place where the bakery takes water for its needs is not high enough, so the bakery's water supply system includes two booster pumps (one for the old boiler house, the other for the bakery) that provide a head of up to 5 meters and have a 2 5-kW drive each The pumps are switched on and off manually in case of a pressure fall in the city water pipelines Water consumption accounting, both for the boiler house and the main territory, is based on the readings of a commercial meter Waste is piped by gravity

4 2 Analysis of Energy Consumption and Costs

During the energy audit of the Permkhleb State Company the fuel-using equipment was being repowered from fuel oil to gas In the future the bakery will use only gas, electricity and water The report analyzes the bakery's energy consumption in 1997, when the ovens and the boiler house fired fuel oil
The table in Attachment II provides data on energy consumption by the shops in 1997 by month

Bar chart 4 2 1 demonstrates energy consumption related to output in 1997 Energy consumption and output are expressed in conventional units, as against January 1997

Bar Chart 4 2 1 Energy Consumption ahainst Output in 1997 r

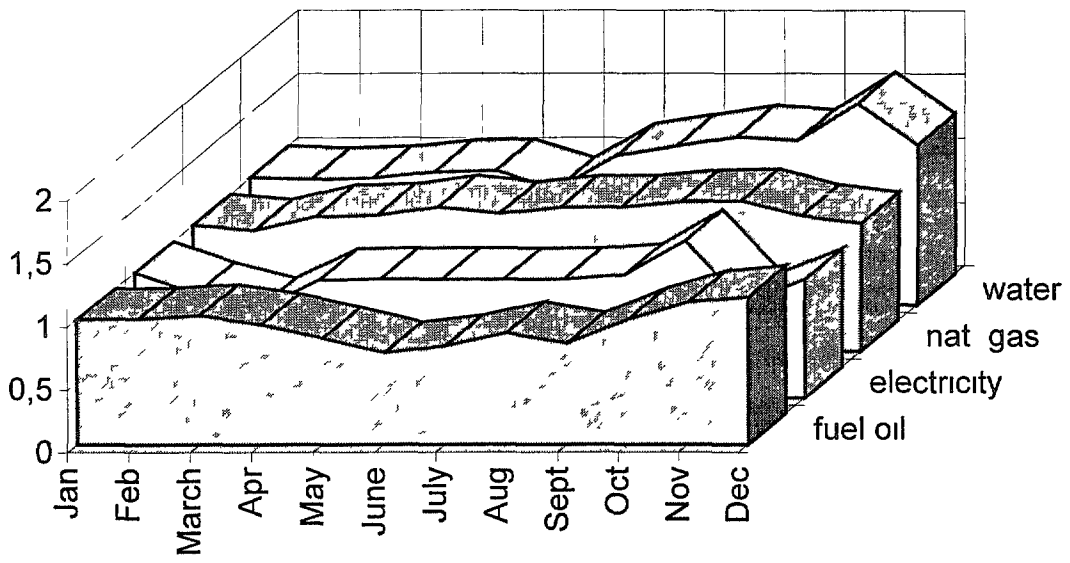


Table 4 2 1 below shows tariffs for energy resources in March 1998 These data were used as input information for the calculations

Table 4 2 1 Energy Resource Tariffs in 1997 – 1998

№	Energy Source	Unit	Tariff, rubles	
			1997	from 03 01 1998
1	Electricity	kWh	0 303	0 303
2	Fuel oil	ton	450	450
3	Gas	m^3	--	0 2935
4	City water consumption discharge	 m^3 m^3	 3 3 2 324	 3 3 2 32

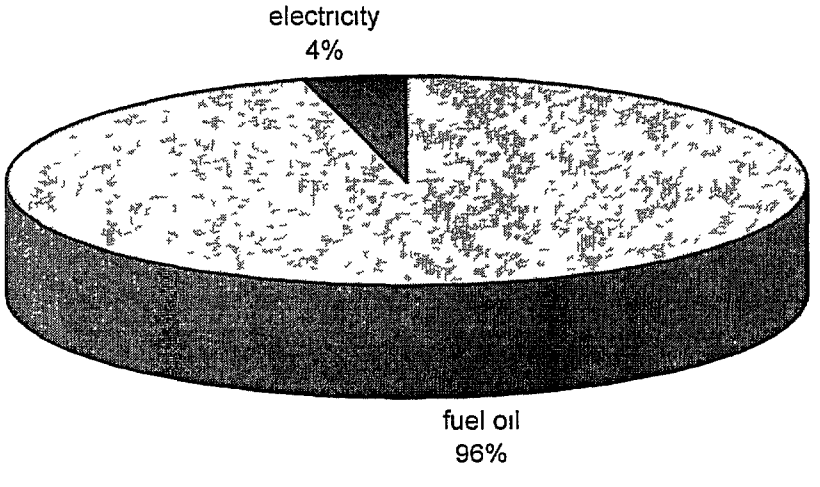
Table 4 2 2 gives information on the bakery's total energy consumption expressed in the power equivalent units

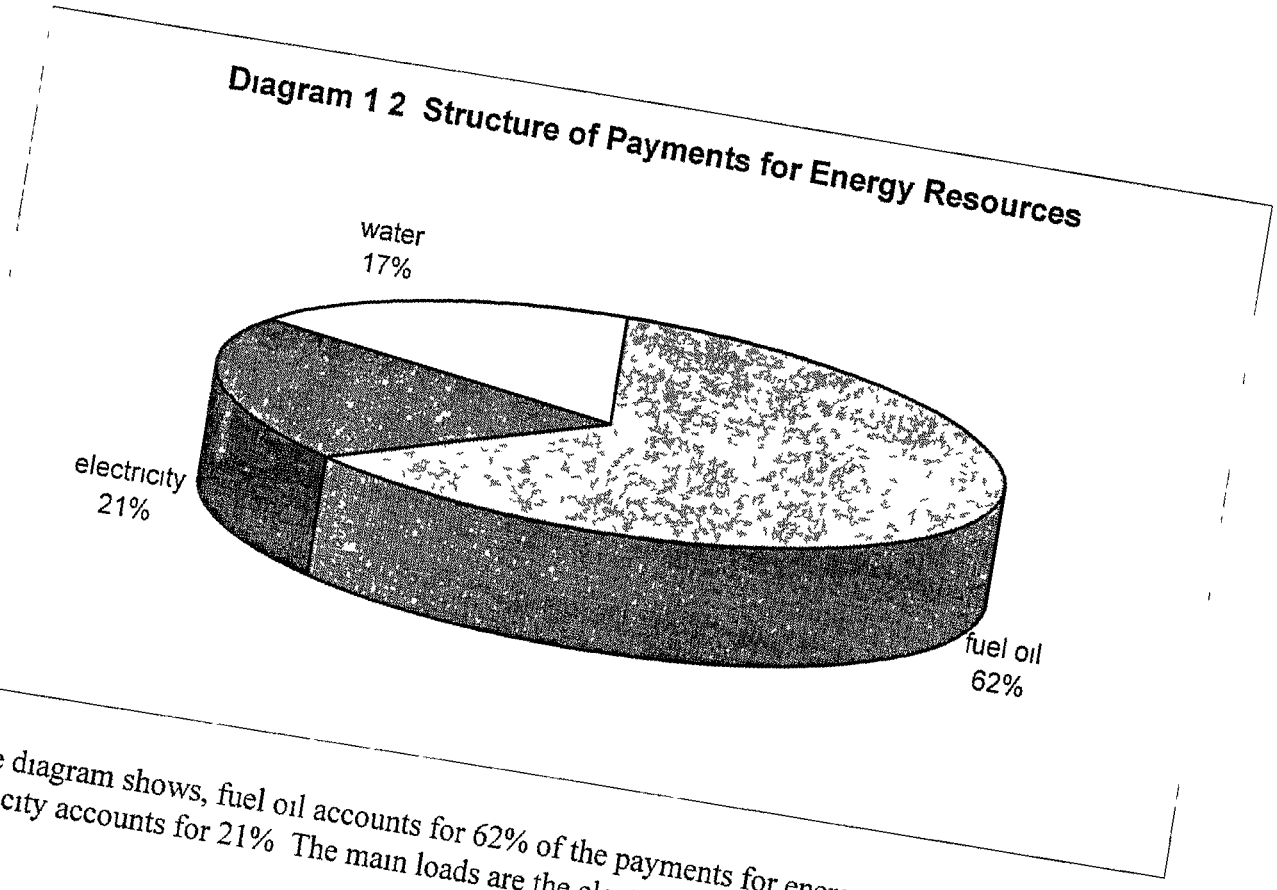
Table 4 2 2 Energy Consumption and Payments in 1997

Energy Source	Unit	Consumption	Energy		Cost	
			GJ	%	ths rubles	%
Fuel oil	ton	1367	54,399 15	95 7	615 38	62 2
Electricity	MWh	673 2	2,423 44	4 3	203 97	20 6
City water	ths m^3	39,589	--	--	170 14	17 2
Total			56,822 59	100	989 49	100

Diagrams 4 1 and 4 2 below demonstrate the structure of energy consumption expressed in the power equivalent and the structure of payments for energy resources used by the main facilities of the bakery

Diagram 1 1 Energy Consumption Structure





As the diagram shows, fuel oil accounts for 62% of the payments for energy resources Electricity accounts for 21% The main loads are the electric ovens

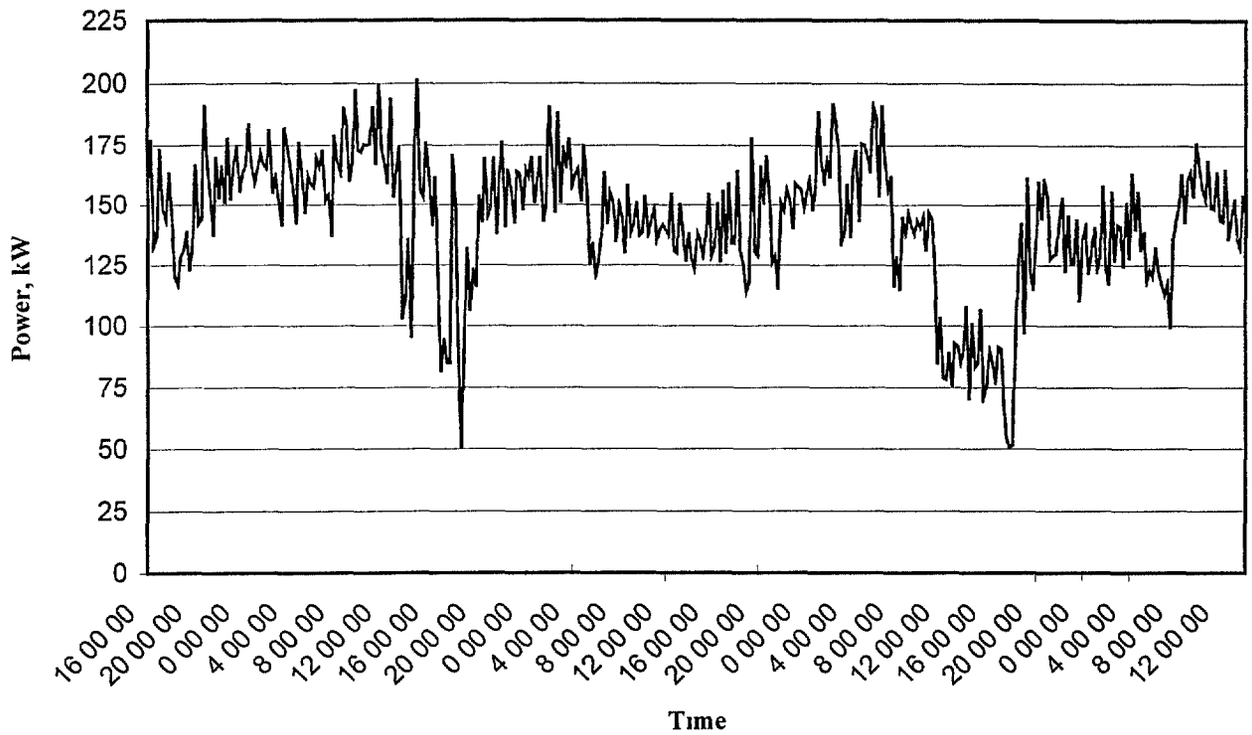
5 Energy Efficiency Measures

5 1 Results of Measurements Taken at the Enterprise

In the analysis of power consumption, energy recorders, Elite loggers and a Fluke multi-meter were used For the purposes of the energy audit, energy recorders were set on the two electricity meters installed at the service entrances, through which power is supplied to the main premises of the bakery

Figure 5 1 1 shows the bakery's load curve in the period between May 21 and 25, which was obtained by adding up power consumption at both inlets

Figure 5 1 1 Aggregate Load Curve in the Period between May 21 and 25, 1998



Additionally, to obtain a daily load curve, analogous instruments were installed at

- the feeder of the block SP4, which powers the fans of the pneumatic transport for flour, the electric ovens KEP-600 and HPA 10-A, two proofers, the white loaf line, the window fan and the ventilation set of the bakehouse,
- the control cabinets SU-1 and SU-3 of the bakehouse (see Figure 4 1),
- the feeder SP-10A of the confectionery shop, which powers 5 electric cabinets, the refrigerant compressor, the electric oven, the rolling machine, the cream beating machine and exhaust fan #3,
- the feeder of the block SP-9, which powers the rest of the confectionery shop equipment

Analysis of the load curves presented in Attachment IV shows that the block SP-4 that powers the electric ovens in the bakehouse is the main load of the bakehouse and of the entire bakery

Parallel to the recording of the load curve with the energy loggers, once-only measurements of power consumed were taken at the majority of the functioning loads in order to put together an energy balance of the bakery and to observe the operating conditions of some of the units

Table 5 1 1 Measurements of Power Consumed by Energy Equipment

№	Name of Equipment	Installed capacity, kW	Consumed power, kW	cos φ	Load factor, F_l
First floor					
Electric ovens					
1	Oven №1 (KEP-600)	39 4	6	0 93	--
2	Oven №2 (KEP-600)	39 4	11 1	0 97	--
3	Oven №4	112 5	63	1	--
4	Titan heater	11	10 7	1	--
Lighting					
1	A	--	0 78	0 84	--
2	B	--	0 59	0 61	--
3	C	--	0 52	0 59	--
Ventilation equipment					
1	Forced ventilation fan of oven №1	3	0 2	0 3	0 1
2	Forced ventilation fan of ovens №2 and №3	5 5	1 1	0 32	0 2
3	Window fan	1 5	1 29	0 55	0 9
4	Blower №1	11	2 77	0 49	0 3
5	Exhaust fan V-1	5 5	3 4	0 6	0 6
5	Exhaust fan V-2	5 5	3 1	0 6	0 6
6	Forced ventilation fan P-1	5 5	3 2	0 7	0 6
7	Forced ventilation fan P-2	5 5	2 5	0 65	0 5
Second floor					
1	Baking cabinet in the confectionery shop (4 pieces)	19 5	19 5	1	--
Lighting					
1	A	--	3 2	0 99	--
2	B	--	0 85	0 86	--
3	C	--	1 32	0 72	--
4	Kneading machine №4	4 5	3 1	0 67	0 7
5	Watch room, gate	--	0 33	0 34	--
Ventilation equipment					
1	Exhaust fan above oven №1	2 2	0 17	0 38	0 1
2	Exhaust fan №1 in the confectionery shop	1 1	0 22	0 41	0 2
3	Window fan in the confectionery shop	1 1	0 29	0 23	0 3

According to the above data, a considerable number of electric motors have low load and power factors The low power factor proves that electric motors have low efficiency and consume too much reactive energy

The weighted average power factor is 0 56 Electricity losses in motors can be evaluated by the reference nomograph

Losses in a motor are calculated according to the following formula
$\Delta P = P_2 \times (1-\eta)$, where
P_2 – useful shaft power (relative value) – 0 26
η - the motor's efficiency – 0 78

The normative loss rate for electric motors is 1 5% With 88,000 kWh annually consumed by the electric motors indicated in Table 5 1 1, losses make 5 72% Thus, above-the-norm losses amount to 4 2% or 3 7 thousand kWh (1120 rubles in terms of money) It must be mentioned that motors with efficiency below 0 45 are to be replaced with less powerful ones

Based on the measurement results, an energy consumption balance of the bakery was put together Please note that the balance includes only the main premises (the old boiler house excluded), because in 1998 the new boiler house will be put in operation Table 5 1 2 shows the bakery's power consumption structure

Table 5 1 2 Energy Balance

№	Load	Electricity consumption,%
1	**Lighting**	7 0
2	**Ventilation**	10 5
3	**Technology, including**	75 8
	Bakehouse	58 2
	Confectionery shop	17 6
6	**Refrigeration equipment**	1 5
7	**Miscellaneous**	5 2
	ИТОГО	**100**

The lighting load was evaluated on the basis of the current operating conditions of individual units and departments and the total capacity of the installed lighting equipment in each room (see Attachment VI), and also on the basis of measurements (see Table 5 1 1)

The ventilation load assessment was based on the results of measuring the consumed power of the operating ventilation equipment

Miscellaneous lord includes the load of the dough-kneading department, the pneumatic transport fans and other unrecorded loads

Gas ovens

In order to analyze the efficiency of fuel combustion, the air-tightness of the smoke flue and to determine potential recovery of the heat of flue gases from the gas ovens, the composition of the flue gases and their temperature were measured with a Bacharach gas analyzer in the section

of smoke flue #3 after the gases passed through the baking chamber and before they reached the main flue
Table 5 1 3 shows the measurement results

Table 5 1 3 Analysis of Smoke Gases from the Gas Ovens

Название переменной	Unit of measurement	Test №
		1
Test date		May 23
Test time	h m	10 30
Flue gases behind the furnace chamber		
Temperature	°C	384
Oxygen, O_2	%	13 3
CO_2	%	4 3
Surplus air	%	159
Heat losses with flue gases	%	32 8
CO	ppm	26
NOx	ppm	28
CO incomplete combustion losses	%	
Oven efficiency	%	67 2

To determine the effectiveness of heat insulation, the temperature of the oven brickwork was measured

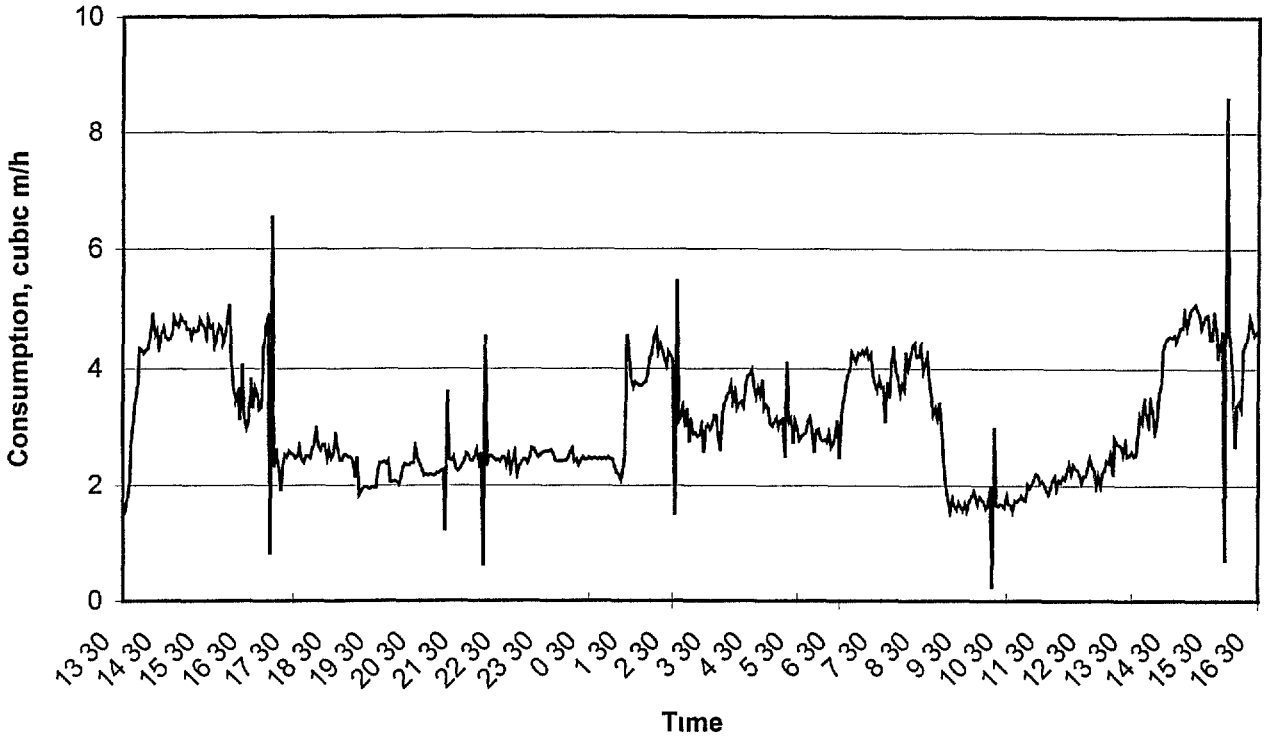
Heating and Ventilation System

For the time being it is difficult to evaluate the functioning of the heating system because it is being overhauled

Hot Water Supply System

In order to identify the daily water consumption profile, a Panametrics ultrasonic flow meter was installed at the hot water pipes through which hot water is supplied from the storage container Based on the measurement results, a daily water consumption curve was constructed (Figure 5 1 2)

Figure 5 1 2 Water Consumption for HWS Needs on May 25-26, 1998



Daily hot water consumption was 70 6m^3

During the measurement period the readings of the cold water meter were registered Daily cold water consumption by the old boiler house and the bakery was about 152m^3

5 2 Possible Energy-Saving Measures

The main electric load at the bakery is the technological equipment A specific feature is that lighting and ventilation account for a big share of the total load

It must be mentioned that recent decisions to modernize the energy-using equipment and the technological processes will substantially reduce the bakery's power demand The most important of the decisions are the construction of the new boiler house on the main territory of the bakery and the repowering of the ovens from fuel oil to natural gas This will exclude condensate losses (currently, condensate is totally lost) and will improve the technical and economic performance of the ovens FTL-2

Great fuel savings will result from the on-going switching of the heating system from steam to water with the installation of the Transsonic spray atomizer

The survey and instrumental measurements have revealed possibilities for improving energy efficiency at the bakery

For example, almost all of the hot water pipes and the hot water storage tank are not insulated Insulation of these elements would save 21 3 thousand m^3/hour of natural gas per annum (Project 1)

There are great heat losses from the KEP and HPA electric ovens, which leads to excessive consumption of expensive electric energy and also deteriorates the working conditions for the personnel Insulation of the outer surfaces of the ovens will save 172 thousand kWh (Project 2) and improve the working conditions in the shop

Since a big part of the bakery's operations take place at night, introduction of time-of-use tariffs for electricity is of great interest The results of electricity consumption measurements taken during several days prove that and makes it possible to estimate how much money could be saved if differentiated (day-time, night-time, peak-load) electricity tariffs were introduced Annual savings could be 8250 rubles (Project 3) For the purposes of estimation it was assumed that the night tariff is 25% lower than the day-time tariff, but according to the most recent data received from Permenergo, prompt payments for electricity can reduce the night tariff by 35%, which improves the project's economic effect

One of the most efficient ways of reducing fuel consumption by the ovens is to increase their load, which largely depends on orders for the bakery's products Being underloaded, the ovens stand idle 4-5 hours a day or even more Start-up time after a shut down depends on the temperature of the oven brickwork, which in its turn depends on the duration of an outage and its technological conditions If outage duration depends on the number of orders from customers, heat losses from an idle oven can be substantially reduced by covering the windows of the baking and furnace chambers and the slide valve at the gas outlet with insulation materials It would be convenient to make this cover in the form of a shutter, which could be also used during normal operations for reducing heat losses into the shop Natural gas savings through heat-up time reduction alone will be at least 21 5 thousand m^3 a year (Project 4) When the shutter is partly lowered, the baking chamber window becomes smaller and this can greatly increase possible natural gas savings

Visual inspection and the measurements taken in the hot water preparation system (see Item 5 1) have revealed great possibilities for energy saving Currently, steam is continuously supplied to the hot water tank and there is no water temperature or water level control, which leads to considerable heat losses The circuit between the tanks and the baby boilers installed on the ovens does not function efficiently, because the temperature of circulating water when the water enters the baby boilers is 70–80°C or more, but in the boilers it increases by just 10-15°C The average temperature in the hot water tank is about 85°C Under the existing scheme the heat potential of flue gases from the ovens is not used efficiently

In our opinion, the hot water supply system needs rationalization The measurements of the composition and temperature of flue gases at the furnace chamber outlet made it possible to evaluate the existing heat potential Our estimates show that this heat potential is enough to warm up 3 9 tons of water per hour by 60-65°C The temperature of flue gases in this case will be 130°C Water will be warmed first in the baby boilers and then in the heat exchanger in the main flue before the stack

According to our measurements, daily hot water consumption is about 70 m^3/hour or, on the average, about 3 m^3/hour The curve analysis also shows that sharp fluctuations in water

consumption last for very short periods of time, so the storage tank s capacity (4 5m^3) will considerably smooth down the fluctuations

Since the gas ovens operate less than 24 hours a day, steam supply from the boilers for hot water preparation may be required for 4-5 hours, which was adopted for Project 5 However, the use of flue gas heat from the new steam boilers will substantially reduce the amount of steam needed for water heating Automatic water temperature control will prevent heat losses caused by water overheating, all the more so, as a significant amount of hot water (about 10%) is discharged into the sewerage system when the tank is overfilled Heat and water losses because of the overfilling can be avoided if hot water from the tank is directed into water-cooling units

5 3 Recommended Energy Efficiency Measures

Project 1

Insulation of the Hot Water Pipelines and the Hot Water Tank

1 Savings		
Annual gas savings	21 3 thousand m^3	6250 rubles ($1025)
Total savings		6250 rubles ($1025)
2 Costs (VAT included)		
Mineral wool		430 rubles ($71)
Insulation assembly		260 rubles ($42)
Total costs		690 rubles ($113)
3 Payback period		

Recommendations

Insulation of the naked pipes in the boiler house and in the water heater room

Description

To reduce heat losses from the naked sections of the circuit pipes and the hot water storage tank, which will save 21 3 thousand m^3 of natural gas

Expected savings

Under the existing gas tariffs, the expected savings will be 21 3 thousand m^3 of natural gas, which is equivalent to 6250 rubles ($1025)

Investment requirements

About 1 m3 of mineral wool will be required for the insulation of the hot water pipes and the storage tank The estimated cost of insulation materials (mineral wool and asphalt sheathing paper) and of assembly works is 690 rubles ($113), including VAT

Payback

The payback period will be 2 months The scale of the project does not require an estimation of the internal rate of payback

Implementation schedule

The project can be implemented immediately

Technical risks related to changes in the quality or quantity of products

In this project there are no such risks

Input data and calculations

The total length of the naked pipes of the hot water supply circuit between the tanks and the heat recovery baby boilers is 80 meters The diameter of the pipes is 60 mm The area of the tank surface is 15 5 m^2 Total heat losses from the naked pipes and tanks are 25 6 kW
The economic insulation thickness for these pipes is about 30 mm Losses through insulated pipes are estimated at 3 3 kW
Summing up, insulation will reduce heat losses by 22 3 kW (197 6 Gcal/year), which is equivalent to 21 3 m^3 of natural gas In terms of money, the savings will make 6250 rubles ($1025) The adopted efficiency is 85% Calculations of heat losses through the naked sections of the pipes and determination of the economic insulation thickness were based on reference tables

Insulation of Electric Ovens

1 Savings

Annual electricity savings	172 MWh	52116 rubles ($8544)
Total savings		52116 rubles ($8544)

2 Costs (including VAT)

Insulation material	960 rubles ($155)
Insulation assembly	580 rubles ($95)
Total costs	1540 rubles ($250)

3 Payback period

Recommendations

Insulation of the outer surfaces of the electric ovens

Description

Currently the temperature of the electric ovens' outer surface is about 60–70°C, which is proof of insufficiently effective insulation Additional insulation will reduce heat losses through the oven walls As a result, the ovens' power consumption will be decreased and the working conditions for the operating personnel will be improved

Expected savings

Under the existing tariffs for electricity, the expected savings will be 172000 kWh a year, which is equivalent to 52116 rubles ($8544)

Investment requirements

About 2 m^3 of insulation material will be required for the insulation of the electric ovens' outer surfaces The estimated cost of insulation materials and the assembly works is 1540 rubles ($250), including VAT

Payback period

The payback period will be 1 month The scale of the project does not require an estimation of the internal rate of payback

Implementation schedule

The project can be implemented immediately

Technical risks related to changes in the quality or quantity of products

In this project there are no such risks

Input data and calculations

The temperature of the outer surfaces of electric ovens is 70°C for KEP-600 ovens and 60°C for HPA-10A ovens

Heat losses to atmosphere from the two KEP-600 ovens are 17 4 kW (the area of the outer surfaces S = 28 8 m^2) and from the HPA-10A oven – 10 7 kW (S = 23 5 m^2)

With additional insulation of the ovens, total losses will make about 3 3 kW

Summing up, additional insulation will save about 24 8 kW, which is equivalent to 172000 kWh

Estimation of heat losses through the outer surfaces of the electric ovens was based on reference tables

Introduction of to Time-of-Use Electricity Rates

1 Savings

Annual money savings	8250 rubles ($1352)

2 Costs

Multi-rate meter – 2 pieces (including VAT)	3800 rubles ($622)
Total costs	3800 rubles ($622)

3 Payback period

Recommendations

Installation of multi-rate meters at the two electricity inlets

Description

In the existing operating conditions (when the biggest part of output is produced at night), it is advisable to introduce payments at time-of-use electricity rates

Expected savings

According to our measurements, introduction of time-of-use rates will reduce payments for electricity by 8250 rubles ($1352)

Investment requirements

The approximate cost of two electricity meters (including VAT) will be about 3800 rubles ($622)

Payback

The payback period will be 6 months The scale of the project does not require an estimation of the internal rate of payback

Implementation schedule

The project can be implemented immediately

Technical risks related to changes in the quality or quantity of products

In this project there are no such risks

Input data and calculations

The results of electricity consumption measurements taken at the inlets were used as input data
Consumption in the peak load period ($09^{00} - 11^{00}$, $18^{00} - 22^{00}$) 817 kWh
Consumption at night ($23^{00} - 06^{00}$) 1115 1 kWh
Consumption in daytime ($06^{00} - 09^{00}$, 11^{00}-18^{00}, $22^{00} - 23^{00}$) 1554 9 kWh
Payment at the existing tariff 1056 5 rubles
Payments at time-of-use tariffs 1033 9 rubles
Money savings 22 6 rubles
Taking into consideration the stable character of the bakery's operations, we assume that the selected day is typical from the point of view of electricity consumption Consequently, annual money savings will make about 8250 rubles

Heat Loss Reduction in the Gas Ovens

1 Savings

Annual gas savings	21500m^3	6234 rubles ($1020)
Total savings		6234 rubles ($1020)

2 Costs

Total costs	4000 rubles ($656)

3 Payback period

Recommendations
To reduce heat losses in the gas ovens through the windows of the furnace and baking chambers

Description
Currently there are substantial heat losses through the windows of the furnace and baking chambers, which leads to fuel overuse during the heat-up of ovens after their outages and during normal functioning

Expected savings
Savings of 21500 m^3 of natural gas are equivalent to money savings of 6234 rubles ($1020)

Investment requirements
The approximate cost of insulation on the ovens will be about 4000 rubles ($656)

Payback
The payback period will be 8 months The scale of the project does not require an estimation of the internal rate of payback

Implementation schedule
The project can be implemented immediately

Technical risks related to changes in the quality or quantity of products
In this project there are no such risks

Input data and calculations
According to the bakery's data, the heat-up of the ovens after their outages takes 1 5-2 hours, which leads to substantial heat losses through the open windows of the furnace and baking chambers and via the stack Installation of shutters on the chambers' windows or some other types of insulation will shorten the heat-up period by at least 30 minutes The resulting fuel savings will make about 21500 m^3 of natural gas per annum
If necessary, a slide valve can be installed on the stack of each oven

Rationalization of the Hot Water Supply System

1 Savings

Annual gas savings	204500m^3	60020 rubles ($9840)
Annual water savings	2555m^3	15630 rubles ($2560)
Total savings		75650 rubles ($12400)

2 Costs (including VAT)

Total costs	55000 rubles ($9000)

3 Payback period

Recommendations
The overhaul of the hot water supply system aimed at more efficient use of flue gas heat and reduced losses caused by water overflow and overheating in the hot water tank

Description
In order to reduce hot water losses caused by water overflow from the hot water storage tank and non-controlled steam supply to the tank, we propose

- introduction of automated steam supply control
- use of water overflow for chemical cleaning of the boilers
- better use of flue gas heat from gas-using equipment through the installation of a heat exchanger at the main flue

Expected savings
Under the existing tariffs for natural gas, savings of 204500 m^3 of natural gas are equivalent to money savings of 60020 rubles ($9840)
Water savings will make 2555 m^3 a year, which is equivalent to 15630 rubles ($2560) including payments for water consumption and effluent

Investment requirements
Capital costs involved in the overhaul of the system are estimated at 55000 rubles ($9000)

Payback
The payback period will be 9 months The scale of the project does not require an estimation of the internal rate of payback

Implementation schedule
The project can be implemented immediately

Technical risks related to changes in the quality or quantity of products
In this project there are no such risks

Input data and calculations
The installation of a heat exchanger at the main flue will make it possible to heat up water with the heat of flue gases (without steam supply) during 20 hours a day

The installation of automatic controls on the steam supply line will save about 7 tons of steam a day (2555 tons a year) or 181 8005 m^3 of natural gas
The removal of water overflow into the sewerage system will save about 7 m^3 of water a day (2555 m^3 a year) Heat savings will make 178 Gcal or 22700 m^3 of natural gas
The adopted efficiency is 85%

Attachment 1 Permkhleb's Output in 1997

Name of Product	Unit of measure ment	Months												Year
		Jan	Feb	March	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	
Bread	tons	689	656	733	737	781	744	778	779	807	812	729	688	**8933**
Confectionery	tons	9	12	11	15	15	16	16	17	19	19	19	20	**188**

Attachment 2 Fuel and Energy Consumption by Permkhleb in 1997

№	Energy Source	Unit	Jan	Feb	March	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Yearly
1	**Fuel oil**	т	120 4	120 9	123 8	115 2	102 3	88 0	94 6	107 0	97 0	120 0	136 6	141 7	**1,367 50**
	tariff	rub/t	450	450	450	450	450	450	450	450	450	450	450	450	
	payment for 1997	ths rubles	54 18	54 405	55 71	51 84	46 035	39 6	42 57	48 15	43 65	54	61 47	63 765	**615 375**
2	**Electricity**	MWh	60 292	50 100	42 591	56 594	57 028	56 927	56 734	56 810	58 834	75 158	45 310	56 800	**673 2**
	old boiler house	MWh	4 188	4 980	3 900	4 580	4 000	4 000	3 800	3 400	4 56	4 460	5 188	4 720	51 8
	tariff	rub/MWh	303 0	303 0	303 0	303 0	303 0	303 0	303 0	303 0	303 0	303 0	303 0	303 0	
	payment for 1997	ths rubles	18 268	15 180	12 905	17 148	17 279	17 249	17 190	17 213	17 827	22 773	13 729	17 210	**203 973**
3	**City water**	m^3	2 863	2,821	2 849	2 979	3,010	2 601	3,351	3,565	3 766	3,680	4,515	3 589	**39,589**
	tariff	rub/m^3	3 30	3 30	3 30	3 30	3 30	3 30	3 30	3 30	3 30	3 30	3 30	3 30	3 96
	payment for 1997	rub	9,448	9,309	9 402	9 831	9 933	8 583	11 058	11,765	12,428	12 144	14 900	11,844	130,644
	disposal	m^3	1,231	1 213	1,225	1 281	1,294	1,118	1 441	1,533	1,619	1 582	1,941	1,543	17 023
	tariff	rub/m^3	2 32	2 32	2 32	2 32	2 32	2 32	2 32	2 32	2 32	2 32	2 32	2 32	2 324
	payment for 1997	rubles	2,856	2,814	2,842	2,972	3 003	2,595	3 343	3,556	3,757	3 671	4,504	3,580	39,494
	Total	ths rubles	12 304	12 124	12 244	12 803	12 936	11 178	14 401	15 321	16 185	15 815	19 404	15 424	**170 138**

Attachment 3 Daily Load Curves of Permkhleb's Main Customers

Figure III-1 Load at the inlet from TS-2002 on May 21-25 1998

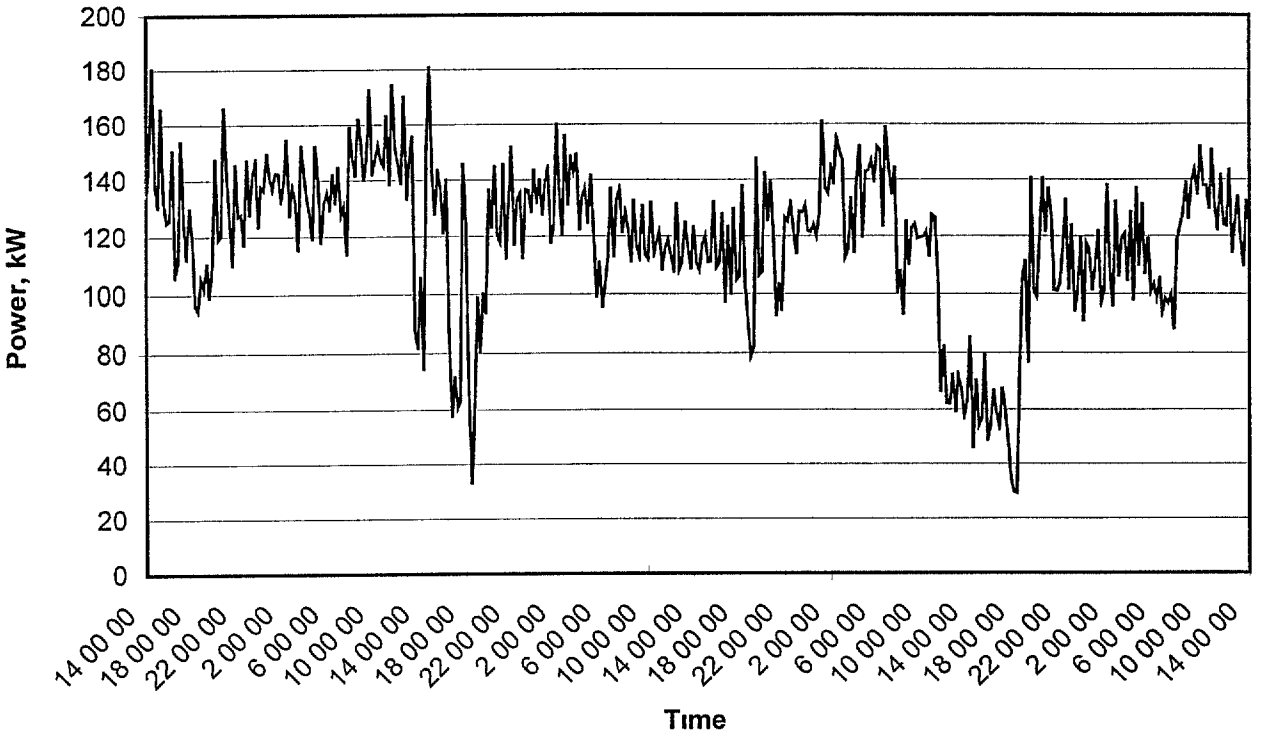


Figure III-2 Load at the inlet from TS-2022 on May 21-25 1998

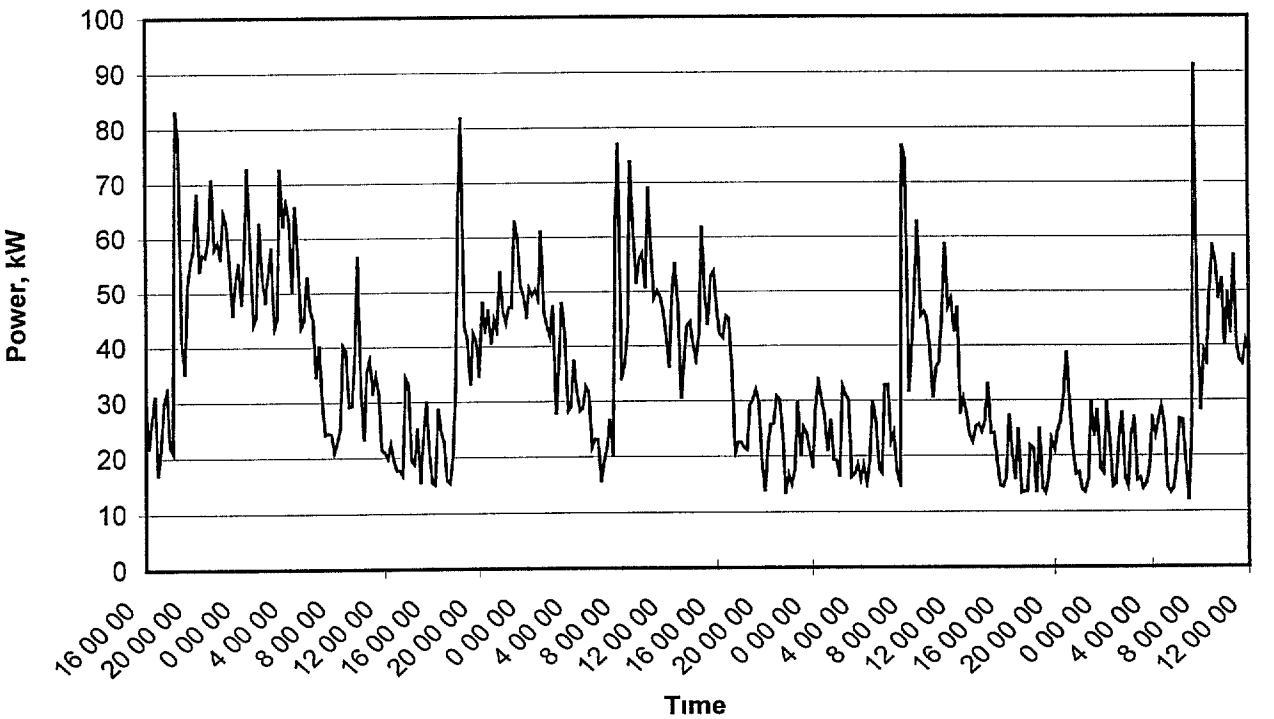


Figure III-3 Electricity consumption from the feeder bushbar SP-4 on May 21-23 1998

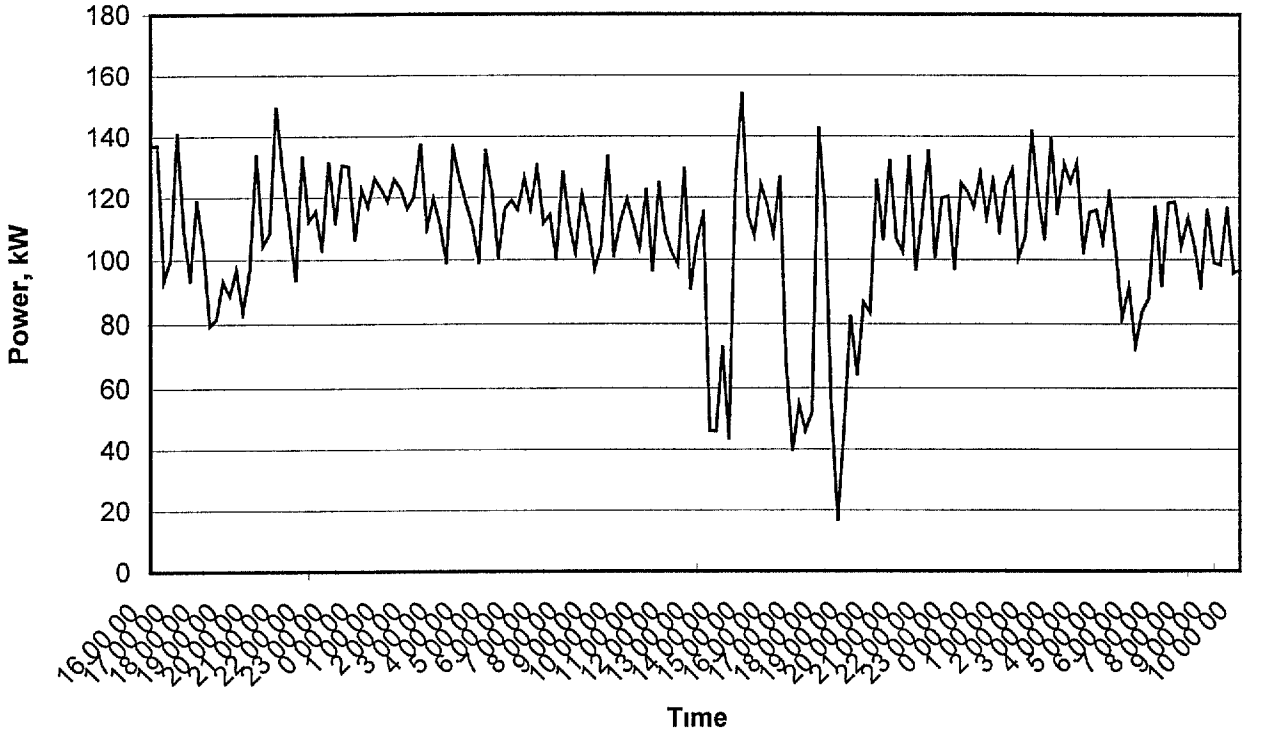


Figure III-4 Electricity consumption by the confectionery shop from the feeder bushbar SP-10A on May 21-23 1998

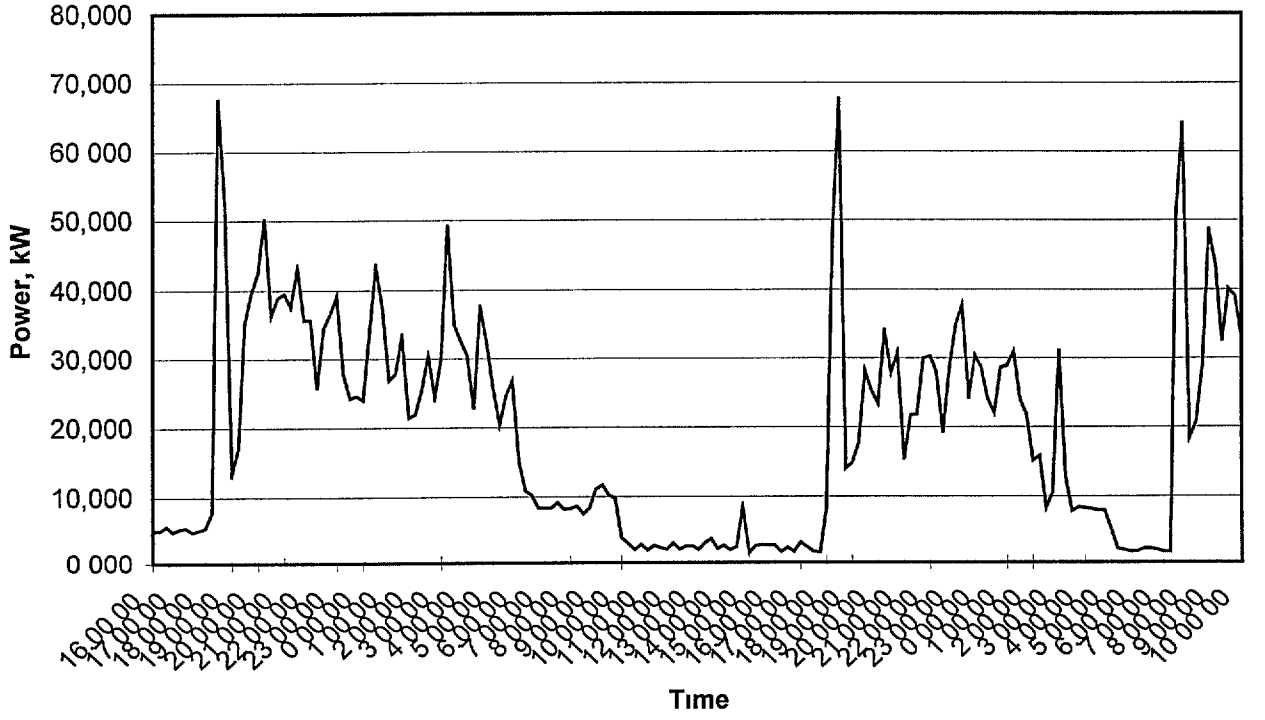


Figure III-5 Electricity consumption by the confectionery shop from the feeder bushbar SP-9 on May 23-25 1998

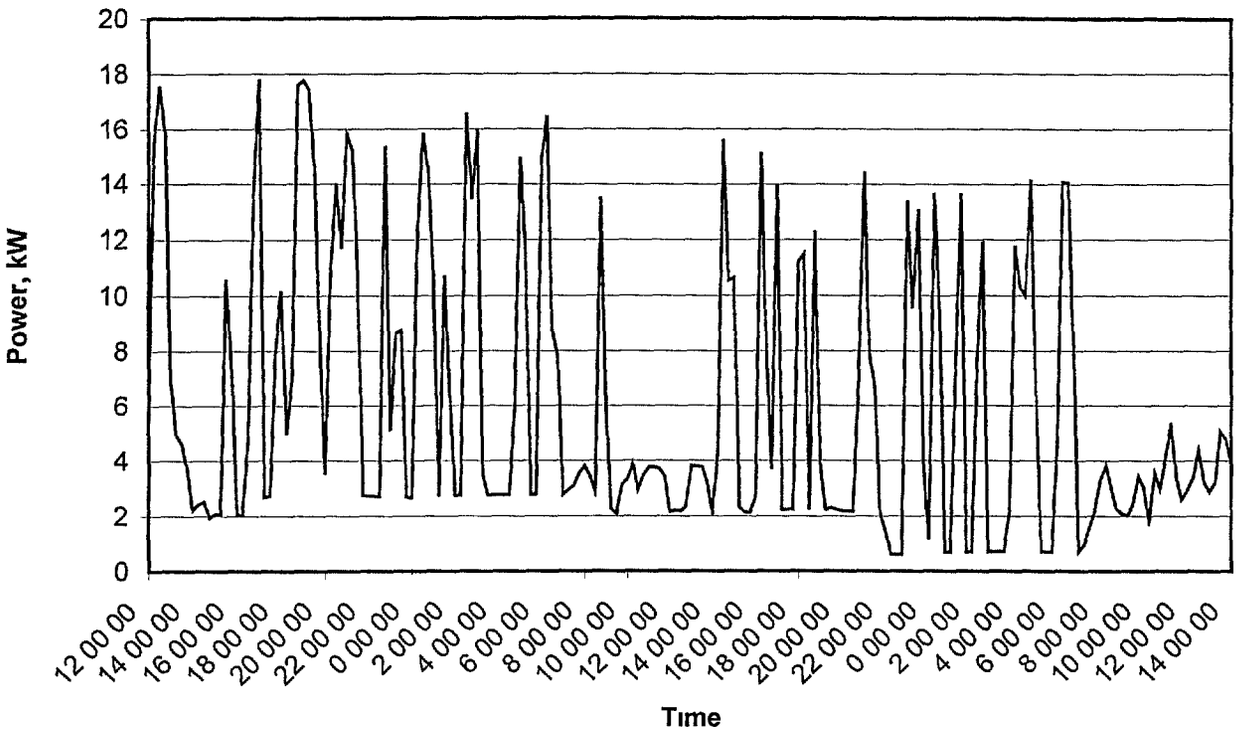
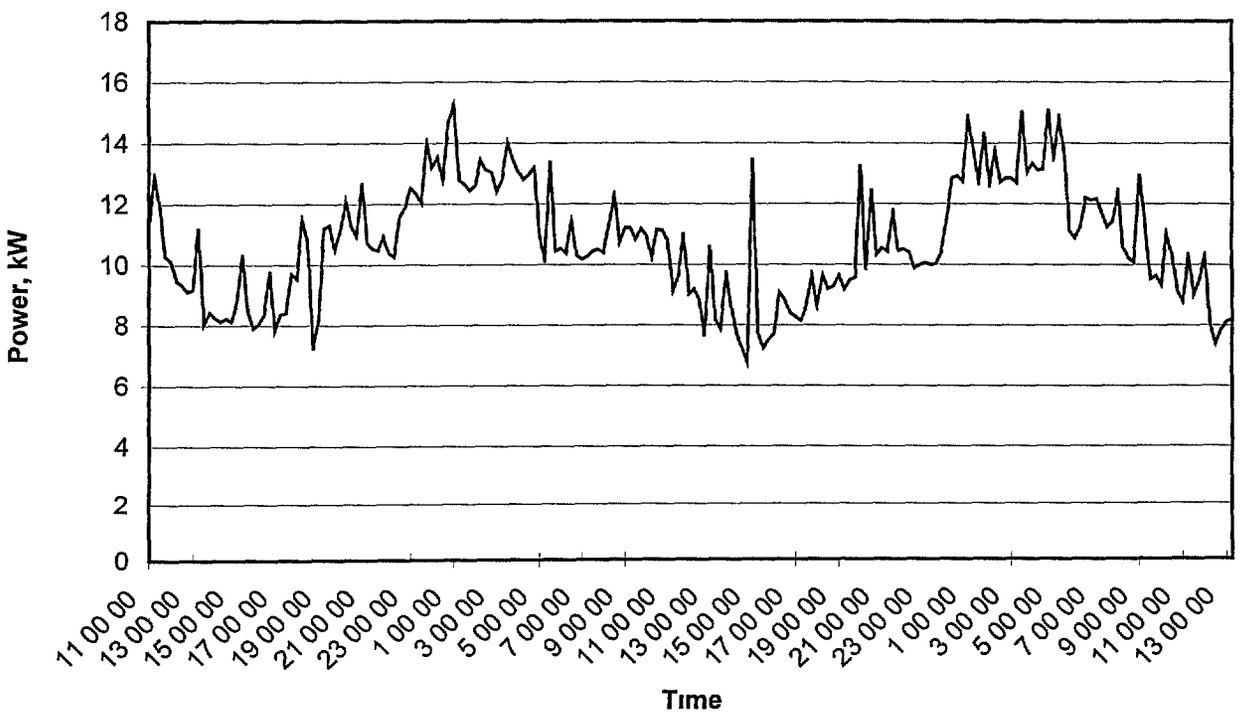


Figure III-6 Electricity consumption by the bakehouse from the feeder bushbar SU-1 and SU-3 on May 23-25 1998



ATTACHMENT IV LOCATION OF LIGHTING EQUIPMENT IN THE ENTERPRISE'S SHOPS

№	Place	Type of Lamp	Quantity, pieces	Total capacity, kW
1	Dough kneading department	LPPR2×40	18	1 44
2	Confectionery shop	—— // ——	38	3 04
3	Bakehouse	—— // ——	21	1 68
4	Dispatch room	PVLM2×40	7	0 56
5	Flour storage	NSPO-100	26	2 08
6	Gas boiler house	NSPO-100	26	2 08
7	Fuel oil boiler house	VZG-200	16	3 2
8	Canteen	incandescent lamp	25	2 5
9	External lighting	НСПО-100	5 14	0 5 4 2
10	Cold store	НСПО-100	12	1 2
11	Laundry	ВЗГ-200 НСПО-100	5 3	1 3 0 3
12	Office	ПСХ-60 5-lamp chandeliers НППО-100	5 5 3	0 3 2 5 0 3
	TOTAL			**27 18**