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ENERGY AUDIT

OAO REINFORCED CONCRETE PLANT NO 2
NOVOSIBIRSK
RUSSIA

Prepared for

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Washington, D C 20253

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TABLE OF CONTENTS

1 EXECUTIVE SUMMARY 1

2 INTRODUCTION 3

3 DESCRIPTION OF THE COMPANY AND TECHNOLOGY 4

3 1 GENERAL DESCRIPTION OF THE COMPANY 4
3 2 PRODUCTION DESCRIPTION 5
3 2 1 Workshop description 5
3 2 2 Process description 7
Gas foamed concrete shop 7
Heavy concrete shop 8
Silicate shop 8
Lime shop 9

4 ENERGY CONSUMPTION PARAMETERS 11

4 1 DESCRIPTION OF EQUIPMENT AND OPERATING PARAMETERS OF THE ENERGY SYSTEMS 11
Electric power supply 11
Lighting system 12
Air supply system 12
Ventilation system 13
Heating system 14
Heat supply for process purposes 14
Heating system and hot water supply system 14
Boiler Station 15
Chemical water treatment facilities 15
Fuel supply 16
Water supply 16
4 2 THE ANALYSIS OF ENERGY CONSUMPTION AND COSTS 17

5 ENERGY EFFICIENCY PROGRAMS 25

5 1 RESULTS OF MEASUREMENTS MADE AT THE COMPANY 25
Compressed Air Supply System 27
Heating system 28
Boiler house 28
5 2 POTENTIAL ENERGY EFFICIENCY PROJECTS 29
Electric power supply 29
Lighting system 30
Compressed air system 30
Heating system 30
Boiler house 31
5 3 RECOMMENDED ENERGY EFFICIENCY PROJECTS 32
Project No 1 32
Project No 2 33
Project No 3 34
Project No 4 35
Project No 5 36
Project No 6 37
Project No 7 38

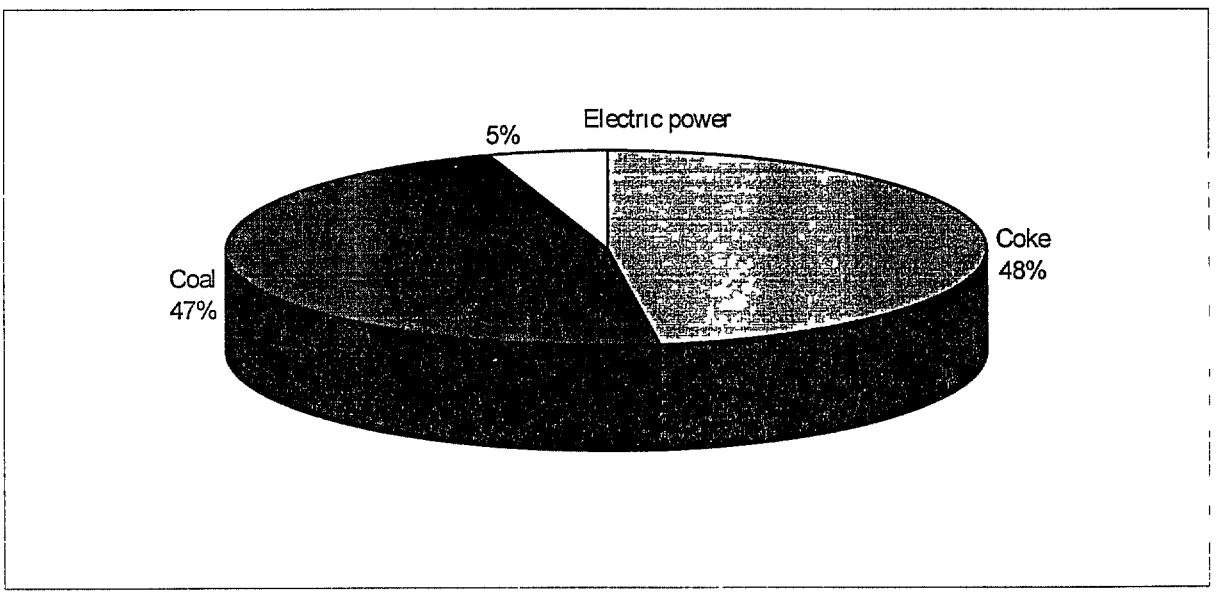
APPENDIX 39

1 EXECUTIVE SUMMARY

This report is the results of the energy audit at the Open Joint Stock Company "Reinforced Concrete Parts Manufacturers No 2" completed in July 1998 The audit was carried out in close cooperation with the Energy Department and maintenance personnel of the Company Officers of OAO "Novosibirskenergo" provided efficient assistance during the course of the audit

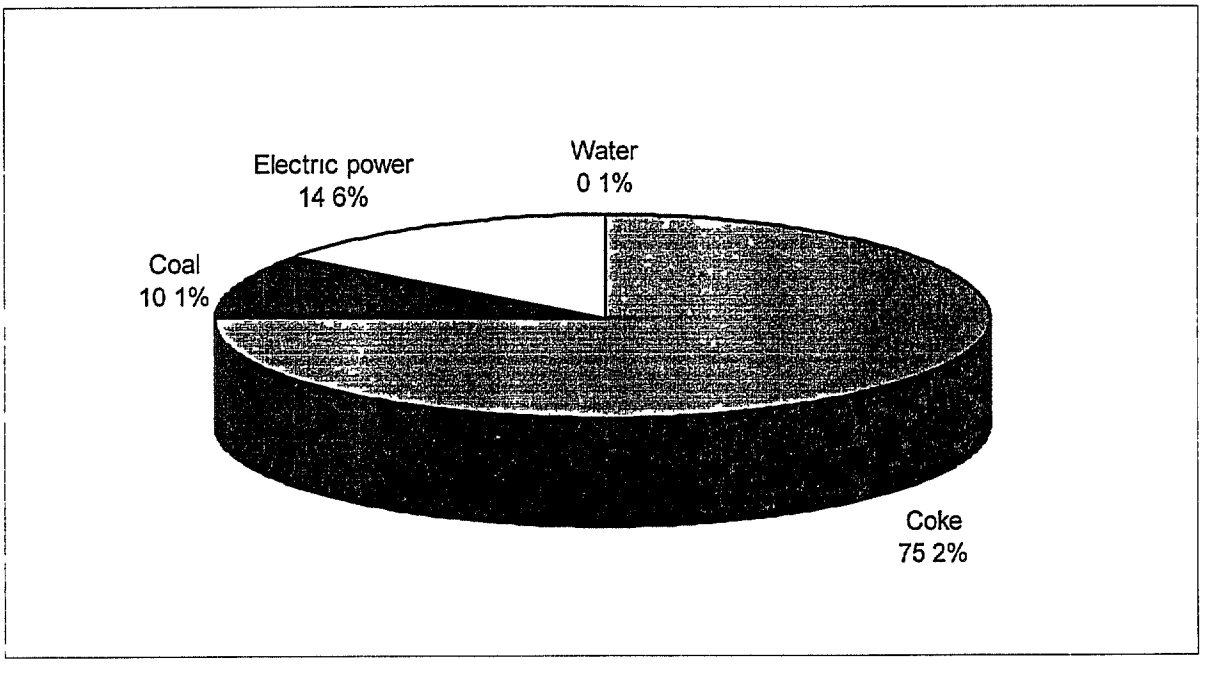
Diagram 1 1 below shows a total energy consumption structure of the Company, which represents the percentage of various utilities consumed by the Company The diagram is based on the designed energy consumption for 1999 According to the diagram, the Company consumes 3 types of utilities coke, coal and electricity

Diagram 1 1 Energy consumption structure



In addition to the utility structure, it is important to understand the structure of energy payments as shown in diagram 1 2 The Company's main expense is the cost of coke - 75 2% with electricity amounting to 14 6% and coal 10 1% The price of water is negligible because the Company has its own artisan water wells

Diagram 1 2 Utility costs structure in 1999



As a result of the energy audit the following energy efficiency projects were identified

Table 1 1 Energy efficiency projects

№	Description	Energy savings,		Project investments, Rubles ($US)	Payback period months
		GJ	thsnd rub ($US)		
No cost and low cost projects					
1	Use vent-steam from the deaerator to heat treated water	24,600	147,000 (23,300)	--	0
2	Install reactive power capacitors	--	5,300 (815)	1,500 (238 1)	4
3	Insulate uninsulated pipes	9,900	59,250 (9,405	11,290 (1,792)	3
4	Reuse steam from the pressure chamber in the Silicate Shop	7,525	45,000 (7,140)	15,000 (2,380)	4
5	Insulate the pressure chamber in the Silicate Shop	23,800	142,500 (22,600)	25,856 (4,102)	3
Middle cost Project					
6	Insulate the pressure chambers in the Foamed Concrete Shop	37,100	222,650 (35 340)	40,960 (6,500)	3
7	Decreasing air inflows in boiler No 8	75,600	42,376 (71,805)	100,000 (15,873)	3
Total		**178,525**	**664,076 (95,606)**	**194,606 (30,889 8)**	**2**

The total reflects the effect of implementing all projects The implementation of the proposed measures will make it possible to decrease the Company's energy consumption by 26 7% It will also decrease the utility bills by 5 8% in relation to the projected energy consumption in 1999 (in the tariffs as of July 1998)

2 INTRODUCTION

The energy audit was carried out by a group of engineers from the East-West Energy Agency (Moscow) within the framework of the USAID project the "Introduction of Energy Efficiency Technologies and Market Reforms in Russia" (Contract No CCN-0020-C-00-152-00) The purpose of this audit was to analyze the energy use, evaluate utility costs, identify inefficient sectors, and develop a comprehensive energy efficiency program

Data on energy usage, process equipment, equipment operation parameters, and the current status of energy/utility distribution systems, etc was gathered during the onsite work This data was analyzed, systematized and presented in this report Data collection was carried out by means of direct measurements, for example, measurement of the capacity of power consuming equipment Calculations were based on design and normative documentation as well as information given by maintenance personnel State-of-the-art portable equipment from Western manufactures was used for direct measurements

3 DESCRIPTION OF THE COMPANY AND TECHNOLOGY

3 1 General description of the Company

The Novosibirsk "Reinforced Concrete Parts Manufacturers No 2" is located in the Pervomaisk District of Novosibirsk and produces construction materials and reinforced concrete structures There are four plants of this type in Novosibirsk The Company was founded in 1964 The following is a description of the main production areas

1 Gas-Foamed Concrete - Shop No 1 Foamed concrete set in pressure-chambers producing reinforced concrete wall panels, ceiling panels and non-reinforced parts (wall blocks, thermo-insulating panels, etc)

2 Silicate Concrete - Shop No 2 Silicate-concrete is set in pressure-chambers producing lime-stone-brick and tiles

3 Reinforced Concrete - Shop No 3 Wall panels for various types of buildings are produced In the Carcass Section of the shop metal reinforcement structures and fillings are welded

Auxiliary production includes lump-lime calcination and lime mills in shop No 5 The Company's main and auxiliary workshops and departments, which do not produce goods, include the transport-feed stock shop (No 6), the repair-construction section (No 8), the repair mechanical section (No 9), the electric-mechanical section (No 10) and steam-power facilities (No 11)

The Company uses purchased feedstock and basic materials Cement is delivered by truck and railway from the Iskitim Cement Plant located 55 km from the plant River sand is delivered from a sandpit located 8-10 km from the plant Lime, for process purposes, is produced directly at the Plant

Steam for process needs communal clients and auxiliary purposes is produced by the Company's boiler house

Presently, the Company is reconstructing almost all its basic production shops Work is being conducted in conjunction with repair work from a major accident in the utility system, which resulted in the plant being shut down for nearly three years

In the course of reconstruction it is planned to switch to a new production technology for tile In addition, a new technology was developed which improved the quality of the foamed concrete

Only the lime shop was operating in a normal mode while the energy audit was being conducted The silicate shop operated periodically The gas-foamed concrete and heavy concrete shops were shutdown to repair the processing equipment These shops should resume operation in December 1998

The Company's 1993 monthly production output by product line is listed in Appendix I

Table 3 1 1 lists the production output and the staff levels for the period of 1993-1997

Table 3 1 1 General Data on the Company

№ п/п	Name	Units	1993	1995	1996	1997
1	*Main production output*					
	Precast concrete	thsnd m^3	15 750	0 051	0 022	--
	Lime-sand brick	million pcs	7 672	1 1	--	--
	Gas-foamed blocks	thsnd m^3	18 017	0 436	0 144	--
	Lime	thsnd tons	10 866	4 04	--	--
	Thermal insulation	thsnd m^3	16 720	2 372	0 912	--
	Tile	thsnd m^2	53 781	7 406	--	--
	Commercial concrete	thsnd m^3	--	0 32	0 069	--
2	*Average Staff List*	people	636	459	279	289

The table shows a sharp decline in production from 1993 until the plant was shut down in 1997

Table 3 1 2 provides the cost structure for production in 1997

Table 3 1 2 Production cost structure per unit expenses

№	Unit expenses	Share, %		
		1993	1995	1997
1	**Production costs, including**	**40 2**	**32 4**	**35 2**
	feed stock and materials	16 3	24 2	22 9
	Fuel	4 5	2 3	4 9
	electric power	19 4	4 1	7 4
	Water	0 07	1 8	0
2	**Payroll**	**23 2**	**16 7**	**44 4**
3	**Social security deductions**	**10 4**	**6 6**	**17 6**
4	**Depreciation**	**1 2**	**16 9**	**--**
5	**Other expenses**	**25**	**27 4**	**2 8**
	TOTAL	**100**	**100**	**100**

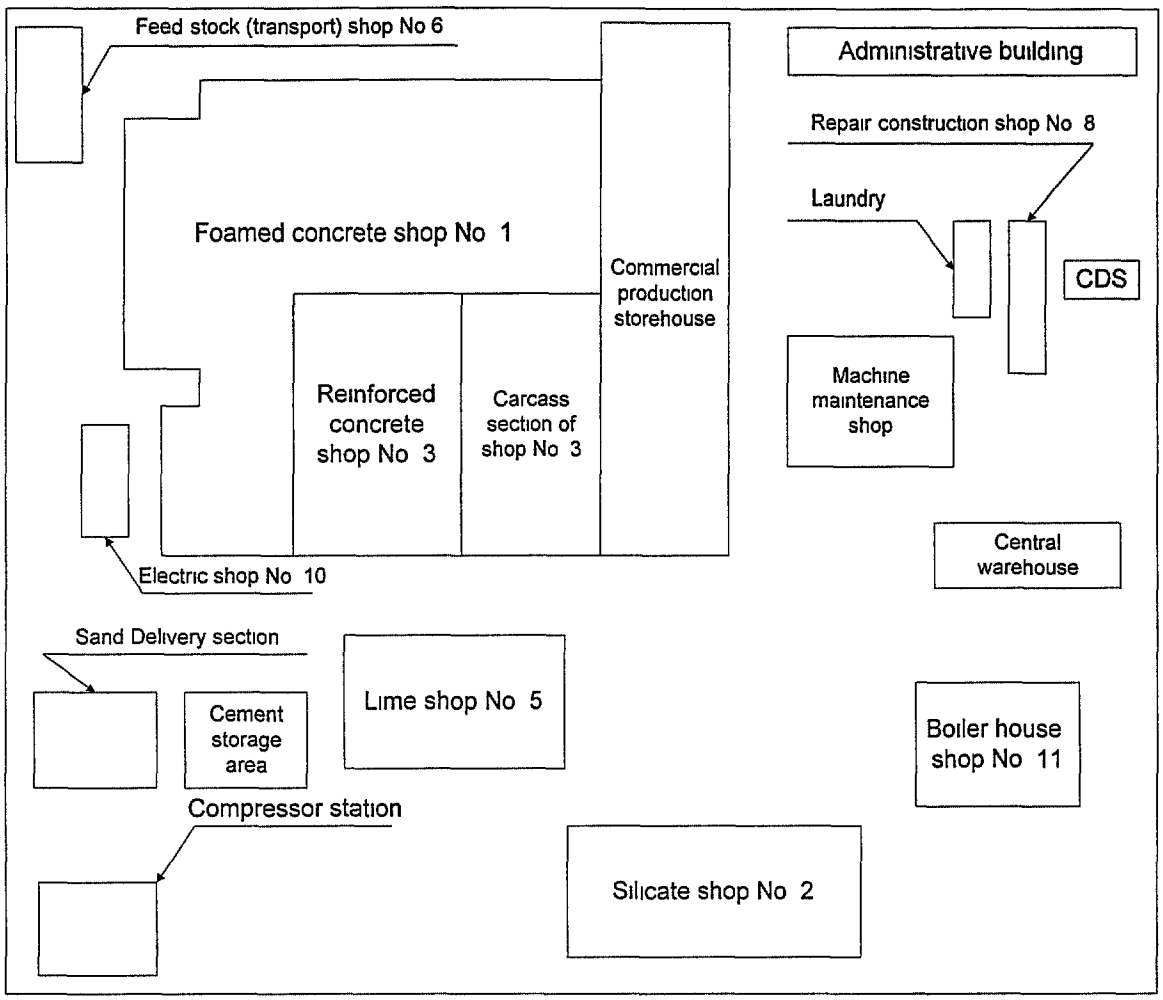
According to the table above the percent cost of electricity and water in the production cost has dropped from 48% in 1993 to 21% in 1997

3 2 Production description

3 2 1 Workshop description

The layout of the Company (see Fig 3 2 1) shows the location of the production buildings and the basic utility facilities

Fig 3 2 1 Layout of the Company



Feed-stock (transport) shop No 6
Administrative building
Foamed concrete shop No 1
Repair-construction shop No 8
Reinforced concrete shop No 3
Carcass section of shop No 3
Commercial production storage area
Laundry
Central Distribution Station (CDS)
Electric shop No 10
Sand Delivery section
Cement storage area
Lime shop No 5
Central warehouse
Compressor station
Silicate shop No 2
Boiler house, shop No 11

The operation schedule for each workshop is provided in table 3 2 1

Table 3 2 1 Operation schedule of the main workshops

№	Shop	Number of shifts	Work hours
1	Gas-foamed concrete	2	16 hours per day
2	Silicate	2	16 hours per day
3	Reinforced concrete	1	8 hours per day
4	Lime	1	12 hour per day
5	Transport	1	8 hours per day
6	Repair-mechanical	1	8 hours per day
7	Compressor station	2	24 hours
8	Boiler house	2	24 hours

3 2 2 Process description

The basic raw materials used in the production process are as follows sand, crushed rock, lime, cement and inert fillers These raw materials are delivered to the Plant by truck and railway Sand, crushed rock and lime are stored in an open-air storage facility Cement brought in by truck and railway is unloaded into silos Cement is carried from the silos by pneumatic transport to distribution hoppers in the workshops

Gas-foamed concrete shop

The production of gas-foamed concrete includes many stages In the grinding section of shop No 1 the sand and ground lime, delivered by the pneumatic transport system from the milling section of shop No 5, are wet-milled Sand is transported from a receiving hopper to the milling section by a system of conveyers Milled lime and sand pulp is pumped to the concrete-mixing section, where they are mixed with a gassing agent (alumna powder) The mixture is poured into molds, where it is foamed and pre-set Here the mixture is provided its initial "raw-strength" Foamed concrete panels and reinforced concrete blocks are produced here In the past, foamed concrete blocks, after they achieve the appropriate raw-strength were cut by special wire The cut pre-set blocks were subjected to a wet thermal treatment until standard final strength was achieved After the reconstruction is completed there are plans to use a new technology, where finished concrete slabs are cut to length This should provide for a higher quality final product and increased production (see table 4 2 1, No 3)

The concrete parts are thermally treated in pressure chambers PNR 2 5x32 with 12 atm and 191^{0}C steam Within the period of 1988 to 1992 ten pressure chambers (one an open-end type) were put into operation in the shop The loading volume of one pressure-chamber is 51 m^3 Thermal treatment takes 11-12 hours The resulting condensate is contaminated with oil and paraffin used for lubricating molds This condensate cannot be returned to the boiler house The contaminated condensate is fully discharged into sewerage and not used for the preparation of the concrete mixture According to the technology applied, after thermal treatment the steam should be bypassed to the pressure-chamber loaded with a new portion of concrete However, due to the absence of a control system and steam bypass pipes, the steam is not being used and is discharged into atmosphere

Reinforcing wire for foamed concrete parts is made of steel rods in the carcass section of the shop by multi-point welding units

In accordance with Plant specifications the following utility standards should be observed thermal insulation, steam - 301 MCal per 1 m^3 of product, water - 0 345 m^3/m^3 and electricity 15 1 kW/m^3, foamed concrete blocks, steam - 345 2 MCal per 1 m^3 of concrete, water - 0 253 m^3/m^3 and electricity 33 9 kW/m^3

Heavy concrete shop

Cement is supplied from the distributing hopper to the concrete mixing section by a conveyer system Inert filler and cement are mixed in a concrete mixer with an appropriate amount of water This concrete mixture is poured into a mobile concrete machine There are three production lines in the shop The concrete machine places the mixture in molds with pre-installed reinforcing wire structures (carcass) The molds are installed on vibrating platforms The concrete mixture is packed on the vibrating platforms The shop has two vibrating platforms with electric drives and one with a pneumatic drive

The concrete is consolidated to industrial grade strength during the thermal-wet treatment in the pit type steaming-chambers The thermal treatment uses steam with a temperature of 96-96^{0}C for 10 hours There are 11 steam-chambers with loaded volumes of 50 m^3 each (dimensions - 7x4x2 4 m) installed in the shop The steaming-chambers were put into operation in 1979 There are also special steam molds for steaming cement foundation blocks, pavement blocks, etc

After steaming in the steam-chambers the consolidated concrete block is taken from the mold and transported by an overhead traveling crane to the warehouse

In accordance with Plant specifications the following utility standards should be observed in the production of the reinforced concrete items steam - 640 MCal per 1 m^3 of concrete, water - 0 2 m^3/m^3 and electric power 11 2 kW/m^3

Silicate shop

The silicate shop produces tile and lime-sand brick

Lump-lime from the lime-receiving hopper is transported to the milling section of the silicate shop Milling is done without water In fact, only one of the two available mills is operating (drives capacity - 160 kW) Conveyers to the batchbox of a two-shaft mixer transport ground lime where it is mixed with sand and water Sand is transported to the batchbox from the receiving hopper by a conveyer system

After the two-shaft mixer, the mixture for tile production is transported to a batch (measuring) box and gas-concrete mixer, and then it is packed on vibrating tables and manually formed After forming, the tiles are sent to pressure-chambers, where they are thermal-wet treated with 10 atm steam After the pressure-chambers the finished product is transported to a finished-products storage area

There are 10 *AP 2x17* pressure-chambers in the shop Three of the chambers were revamped to steam the tiles The loading volume of the pressure-chambers is 150 m^2 of tile with a daily capacity of 165 m^2

After the two-shaft mixer, the mixture for limestone brick production is transported to silos with a volume of 50 m^3 each Here the mixture is conditioned for 3 hours then sent to a rod mixer where it is blended with water Following this stage the mixture is transported by the conveyer system to the press molding Formed green-brick is sent to the pressure-chambers for steaming and then to the finished-products storage area

The pressure-chamber is supplied 8 atm/175^{0}C steam for brick production The daily output capacity for the pressure-chambers is about 16,9 thousand bricks The steaming period lasts 10-12 hours

In the past, used steam from one pressure-chamber was bypassed to the newly loaded one The former pipeline scheme provided for steam bypassing to each of the pressure-chambers This system is currently not operating, because its control equipment is broken

Condensate formed in the course of steaming is discharged into the sewer

In accordance with Plant specifications the following utility standards should be observed for tile production steam - 73 3 MCal per 1 m^2 of tile, water - 0 03 m^3/m^2 and electric power 0 8 kW/m^2

Rated utility consumption per one thousand sandstone bricks is as follows 704 MCal, water - 0 22 m^3 and

electric power 76 7 kW

Lime shop

There are three lime-burning units (height - 17 m, diameter - 3 m, loading volume - 100 tons) in the lime shop The finished product capacity of each unit is 100 tons per day Presently, due to a limited demand for lime, only one unit is operating See data on the use of production capacities in table 4 2 1

Fractionated limestone with 80-120 mm particle size is used as feedstock for the lime production Limestone is supplied to the Plant by railway and transported by a conveyer system to an open-air feedstock storage area It is then loaded by a grip-crane to the distribution hopper, transported by a conveyer belt to a screen drum, where small size particles, dirt and foreign matter are separated Once the limestone is screened it is transported by conveyer belt to the batchbox Components are dozed according to the Plant's laboratory specifications depending on the temperature of the calcination zone, particle size, etc Coke and feedstock are dozed on pallets in layers The dozed batches are lifted on the pallets to the upper part of the oven In the oven the batch is moving downward The temperature of the calcination zone is 1000^{0}C Combustion air is periodically supplied by a fan-blower

Calcined lump lime with the activity of 70% is used for the production of foamed concrete and silicate items It is also sold as a commercial product

The lime is unloaded from the oven through bulk discharge-locks (three stages) onto a plate conveyer and transported to a hammer-crusher Once crushed lime for shop No 2 is loaded onto the conveyer belt and a reverse transporter supplies lime for shop No 1 The crushed lime is transported the elevator to the batchbox of the mill

Lime is dry-milled in the Milling Section There are three ball-mills located in this section with an output capacity of 4 tons per hour each (drives capacity - 160 kW) Usually, only two of the mills are operating After milling the lime it is transported by screw transporters to the milled lime batchbox Here an injector pump pumps it to the batchbox in shop No 1

According to the local production standards, the utility consumption per 1 ton of lime is as follows coke - 240 kg and electricity - 46 1 kW/hour

Table 3 2 2 lists the process sections that are the main users of compressed air

Table 3 2 2 Compressed air end-users

№	Process equipment	Amount, pcs	Air consumption, m^3/min	Pressure, kgf/cm^2	Operation mode, hour/shift
Shop №1					
1	Dozing, Shop №1	1	up to 5	6	1 5
2	Pneumatic vibrating table	1	5 6	6	1
Shop№2					
1	Dozing, Shop №2	1	up to 4	5	1 5
2	Press CMC-152	4	5 6	5	6
3	Pneumatic vibrating table	1	5-6	6	0 5
Shop №3					
1	Dozing, Shop №3	1	up to 5	6	1 5
Shop №5					
1	Lime supply to Shop №1	1	8	6	2
2	Loading locks	1	up to 4	6	3
3	Dozing, Shop №5	1	up to 5	5	3
Cement storage					
1	Pneumatic cement transportation to the hopper	1	10-15	6	1

Practically all shops have small air surge tanks to damper pressure fluctuations in the system caused by the irregular operation of end-users, mainly dozing equipment The operation mode of such equipment is 3-5 minutes for dozing and 20 minute - idle run

The largest compressed air consumer is the pneumatic transport system for cement from the cement storage area to a 20-ton hopper The system operates onetime for two hours over a 2-day period

4 ENERGY CONSUMPTION PARAMETERS

4 1 Description of equipment and operating parameters of the energy systems

Electric power supply

The main production area of the Company is connected to the Energo Grid by means of 10 kV input from the "Novoinsk" substation

Feed-lines from the central distribution station (CDS) are connected to 30 transformer substations (*TP*) with a design capacity of 7,840 kVA, which supply electricity to all departments of the Company and the outside clients Seven substations supply all production workshops and some neighboring outside clients Two substations located beyond the area of the Company supply city water-rising pumps, which pump water for the Company and the outside clients The parameters of the transformers installed at the production support substations are provided in table 4 1 1

Table 4 1 1 Transformers

№	Type	Amount, pcs	Capacity, kW	Voltage U max\U min, kW	Remarks	Location
Transformer substation № 1						shop №1
1	TM	1	630	10/0 4	On-line	
2	TM	1	630	10/0 4	Stand-by	
Transformer substation № 2						shop №5
3	TM	1	630	10/0 4	On-line	
4	TM	1	800	10/0 4	Stand-by	
Transformer substation № 3						shop №2
5	TM	1	560	10/0 4	On-line	
Transformer substation № 4						boiler house
6	TM	1	630	10/0 4	On-line	
7	TM	1	560	10/0 4	Stand-by	
8	TM	1	560	10/0 4	Stand-by	
Transformer substation № 5						detached
9	TM	1	320	10/0 4	On-line	
Transformer substation № 6						Compressor station
10	TM	1	560	10/0 4	On-line	
11	TM	1	560	10/0 4	Stand-by	
Transformer substation № 7						shop №6
12	TM	1	400	10/0 4	On-line	
Transformer substation № 11 - pumps of the II stage of city water rising						Settlement
13	TM	1	160	10/0 4	Stand-by	
Transformer substation № 3211 - pumps of the I stage of city water rising						pump station
14	TM	1	320	10/0 4	On-line	

No reactive capacitor units are provided at the substations

Substation *TP*-1 supplies the gas-foamed concrete in shop No 3
Substation *TP*-2 supplies the lime section in shop No 5
Substation *TP*-3 supplies the silicate section in shop No 2
Substation *TP*-4 supplies the end-users of the boiler house and one of the outside clients - a transport company
Substation *TP*-5 supplies the repair-mechanical and construction workshops, canteen, administration building, medical center and laundry
Substation *TP*-6 supplies the compressor station and *TP*-7 - the sand-receiving section

Active (F-68700) and reactive (TsE-6801) power meters are installed at the *"Novinskaya"* substation for the commercial accounting of active and reactive power All settlements with the outside clients, with the exception of the neighboring residential district, are made on the basis of readings these meters The consumed load of the residential district is calculated as the difference between the readings of the meter installed at the *"Novinskaya"* substation and the meter installed at the input cubical of the CDS For the purpose of internal accounting meters are installed at the CDS (at each cubical) and some workshops (repair-mechanical shop) Electric power distributed between various sections of the shops is not recorded

Lighting system

The Company workshops are illuminated with different types of lamps Table 4 1 2 provides data on the total capacity of lighting equipment installed in the workshops

Table 4 1 2 Installed electric power load of the workshops

№	Consumption by lamps	Location	Amount, pcs	Installed capacity, kW
Shop №1				
1	ГС500МУ4	shop 1	70	35
2	Ц-27	shop 1	30	7 5
3	Ц-27 (36 В)	Arcade	40	2 4
Shop №2				
4	ГС500МУ4	shop 2	40	16
5	Ц-27 (36 В)	Arcade	30	1 8
Shop №3				
6	ГС500МУ4	shop 3	40	16
7	Ц-27 (36 В)	Arcade	20	1 2
Shop №4				
8	ГС500МУ4	shop 4	20	8
9	СКЗПР-500У1	shop 4	20	5
10	Ц-27 (36 В)	Arcade	30	1 8
Shop №5				
11	ГС500МУ4	shop 5	30	12
12	Ц-27 (36 В)	Arcade	20	1 2
13	СКПВМ-220	shop 5	6	0 24
Shop №6				
14	ГС500МУ4	shop 6	15	6
15	СКЗПР-500У1	shop 6	10	2 5
16	СКПВМ-220	shop 6	6	0 24
Shop №8				
17	СКПВМ-220	shop 8	15	0 6
Shop №9				
18	ГС500МУ4	shop 9	20	8
19	СКПВМ-220	shop 9	6	0 24
Shop №10				
20	СКПВМ-220	shop 10	15	0 6
Production site lighting system				
21	СКЗПР-500У1	lighting posts	50	12 5
	TOTAL			138 82

According to the table the main lighting load is located in the production shops Currently a majority of the lighting equipment in the production shops is not use

Air supply system

The air supply system is a centralized type with a detached compressor station building Table 4 1 3 lists the air compressors installed

Table 4 1 3 Air compressors

№	Compressor type	Put into operation in	Amo unt, pcs	Capacity, m^3/min	Pressure,kg f/cm^2	Drive capacity, kW	Cooling system	Water flow rate*, m^3/hour
1	2BM2 5-12/0	1991	2	10	8	55	return	--
2	103 ВП-20/8	1978-81	6	20	8	125	return	2 5

Air pressure of 5-7 atm is maintained in the air system In the event that air pressure in the lines exceeds 8 atm, a relief valve is activated and the compressed air is discharged into the atmosphere

Only one 103 VP-20/8 compressor was operating during the energy audit The compressors operate only during the work-shift They are shutdown at night KhRK-9-0 4 end-coolers are installed after each compressor

Three 6 3 m^3 air surge tanks are installed at the output of the compressor station Two of the tanks were operating with one reserved for stand-by Small 0 65 m^3 air surge tanks are installed in the silicate and lime shops, which are intended to cover the peak demand for compressed air for the dozing (batch weighing) units A similar air tank is installed in the boiler house

The compressors are water cooled The cooling tower for the return cooling water system is not operating, so a temporary recycling water-cooling system was set-up Water is pumped from a tank to the compressor and returned to the tank Water is cooled by means of mixing the hot water from the compressor with the cool water in the tank

Ventilation system

No input ventilation is installed in the workshops Steam heat screens are installed at entrance gates of the gas-foamed concrete, reinforced concrete and silicate workshops A KSk 3-9 calorifer with two ventilators (drive capacity - 7 5 kW) is installed in the gas-foamed concrete shop, a KSk 3-8 calorifer with two ventilators (drives capacity - 4 5 kW) is installed in the reinforced shop and a KSk 3-11 calorifer with four ventilators (drives capacity - 11 kW) is installed in the silicate shop

The exhaust ventilation systems of the main workshops include roof and dust-suction ventilators Eight VKR-5 (drives capacity - 1 1 kW) are installed on the roof of the reinforced concrete shop The ventilators are operated in an intermittent mode and are used mainly to evacuate large amounts of steam coming into the shop when the steaming chambers are opened Six VKR-5 (drives capacity - 1 1 kW) are installed on the roof of the silicate shop and four TsP6-11 dust ventilators (drives capacity - 11 kW) are installed in the mix-preparation shop Sixteen VKR 6 and VKR-3 ventilators (drives capacity - 2 2 kW) are installed in the gas foamed concrete shop Dust is removed in the lime shop by three dust-suction ventilators TsP6 45 (drives capacity - 15 kW)

Heating system

The company's boiler house supplies the entire company's heating energy for processing, heating, ventilation and hot water supply (HWS) In addition, heating was supplied to outside clients in the past The main outside client was the residential district Heat was supplied to a closed loop scheme at a water temperature of115-70^{0}C Presently heat is only supplied for internal needs

Heat supply for process purposes

Only one heat carrier produces steam for process needs Hot water is not used for processing The main end-users of steam are the pressure-chambers in the silicate shop, the gas-foamed concrete shop and the steaming chambers in the heavy concrete shop According to the boiler house personnel, the steam pipeline system is operable, however, some pipe sections should be replaced A new 130m pipeline without thermal insulation has been connected to the silicate shop A steam pipeline in the gas concrete shop is insulated, but only 20% of the pipelines in the remaining shops are insulated

Heating system and hot water supply system

Before the industrial accident the company used a combined heating system with steam as the heat carrier in the production workshops, the administrative building and canteen The construction and repair-mechanical shops are heated by delivery water, which is taken from the heating mains supplying heat to the settlement The deliver water for heating is prepared in steam-water boilers (5 units) installed in the boiler house After two water-heating boilers were put into operation, the boilers of the heating system were used only to cover peak consumption, when the boilers could not generate a sufficient amount of heat

Presently, the Cotton Factory supplies heat to the residential district (settlement) This makes it possible to use only steam as the heat carrier in the heating system of the Company

In 1991 an outside organization developed a project to replace steam used in the heat supply system of the Company with water The use of water as the heat carrier features some advantages over steam, for example, it provides an opportunity to install a centralized control for uniform heating loads It also increases the efficiency of the heat supply system due to the lack of condensate and steam losses to the end-user in contrast to steam-type systems and increases accumulating capabilities of the system Unfortunately, this project was not implemented for reasons unknown Now, during the reconstruction period characterized by small production output and limited financing, the management of the Company decided to restore the steam heating system Perhaps, it is a rather practical approach in the current situation, because the most crucial problem faced by the Company is to restore production In this respect, some decisions are made, which, on the one hand, are not the best from the point of view of energy efficiency, but, on the other hand, do not require big investments In this particular case, the repair of the steam heating system would require minimum expenses Steam to this system will be supplied from the existing process pipeline, which would not require the construction of new pipelines and the replacement of steam calorifers with water ones

Condensate tanks were installed in the steam heating systems of the basic production workshops (gas concrete, silicate, reinforced and lime shops) Condensate was collected and pumped to the boiler house and then to the chemical water treatment facility (CWTF) Condensate was returned by pipelines located near the steam supply pipelines under common thermal insulation, thus used as tracer-pipes for the condensate line, preventing them from freezing There is no insulation on the condensate tanks The steam-condensate blend was fed to the upper part of the tank, which increased condensate losses In the event that the system is restored, the steam-condensate blend should be fed in such a manner that it bubbles through the layer of condensate The condensate tanks should also be insulated A visual inspection of the condensate tanks found them in unsatisfactory condition (rusted) From the two-condensate tanks in the shop, the condensate was sent to two 20 m^3 accumulating drums located in the boiler house, blended with fresh water and sent to the chemical treatment facilities

Hot water, from the hot water supply system, is prepared separately in each shop in special boilers heated by steam The HWS boiler is a water filled pressure-vessel with a steam-coil inside With the exception of the gas concrete shop, where steam is sent to the condensate tank of the steam heating system, all steam-condensate after the boiler is discharged outdoors No automatic control of the steam supply to the boiler, depend on the hot water temperature, is available Practically all boilers had insulation Water heated in these boilers is used for showers

Boiler Station

The boiler station is designed to generate 13 bar steam for heating, ventilation, the hot water supply for the residential district and the production process

Five KE-10/14 steam boilers and three DKVR-10/13 boilers operating in the water-heating mode are installed in the boiler house The capacity of the steam boilers is 10 tons of steam with a pressure of 13 atm The boilers, designed to use solid fuel (black and brown long-flame coal), were put into operation between 1976 - 1981 The boilers', designed by Biysk Boiler Manufacturers, include two drums, a furnace chamber and branched convection pipe bundles without a steam overheater The furnace is equipped with a band reversible glass with pneumatic coal spreaders Scrapers remove ash The EP1-330 BTI Economizer is a module type made of cast-iron Dry ash is removed from chimney gases with a series cyclone separator, type BS-2-7x

There are two 50-m3 deaerators equipped with OVA-2 vented-steam coolers installed in the boiler house The design of the boiler station included the installation of a heat exchanger to heat treated water after the deaerator However, the heat exchanger has not been used over the passed 10 years

Three feed pumps are installed to supply feed-water to the boilers

The parameters for pumping and auxiliary equipment are given in tables 4 1 4 and 4 1 5

Table 4 1 4 Pumping equipment

№	Name	Type	Amount, pcs	Flow rate, m^3/h	Head, m	Rotation speed, r p m	Drives capacity
1 Pumps of the heating system installed in the boiler house							
	Feed	ЦНСГ-38-250	3	38	250	2,940	55
	Delivery	Д320-50	2	325	49	1,475	200
	make-up	К-20/30	2	20	30	1,000	4
	Condensate	н/д	2	250	30	1,500	40
2 Water supply system							
	artesian water	ЭЦВ-8	1	10	60	2900	13
	I City water rise	Д-320/80	3	320	80	1500	75
	II City water rise	Д-320/80	3	320	80	1500	75
3 Return cooling water pumps for compressors							
	to compressors	2К-6	3	20	30	2900	7 5

Chemical water treatment facilities

The chemical water treatment facilities treat feed-water for boilers and replenish delivery water losses The water treatment process is carried out by pumping fresh water from the surge tank into two $450m^3$-clarification tanks for water settling Water is then pumped by four TsNS-180/60 pumps to a mechanical filter, where the water is filtered through a layer of quartz sand It then goes to the chemical water treatment facilities There are four filters in the boiler house operating in a two-stage water treatment scheme with two filters in both the first and second stage Sulfated coal is used as a filtering material

The hardness of treated water after the first stage does not exceed 15-20 mkg equ /l The first stage filters are regenerated 1-2 times per week and the second stage filters are regenerated once per month

Fuel supply

The Plant's fuel supply system includes an open coal storage area with a 30 dav operating supply Coal from the receiving hopper is sent through a feeder to a band conveyer operated by a KO-22/8 electric drive The coal is crushed to a particle size of 1-50 mm The band conveyer equipped with scraper spreaders then transports the coal to the boiler hoppers

Table 4 1 5 Auxiliary equipment of the boiler house

№	Equipment	Unit	Amount, pcs	Performance
1	*Economizer*		*8*	*ЭП-1-330/ВТИ*
	heating surface	m^2		330
2	*Blower*		*8*	*ВД-10*
	Capacity	nm^3/hour		13,100
	Head	mm water clmn		94
	r p m	min^{-1}		980
	motor capacity	KW		11
3	*Smoke extractor*		*8*	*Дн-12 5*
	Capacity	nm^3/hour		39,000/26,000
	Head	mm water clmn		360/150
	r p m	min^{-1}		1,500/1,000
	motor capacity	KW		75/55
4	Delivery water boiler I stage		3	МВН 1436-06
	steam pressure in vessels	kgf/cm^2		10
	steam pressure in pipes	kgf/cm^2		16
	heating surface	m^2		62 3
5	Delivery water boiler, II stage		2	630-25-100-2ТП
	steam pressure in vessels	Atm		<7
	heating surface	m^2		100

Water supply

The pipeline connected to the City Water Supply System covers the Company's process and domestic water requirements The total length of external water supply pipelines is 7 km, including an intermediate pump station All settlements with the city water supplying Company are made in accordance with the readings of the commercial meter The city water is elevated by the number I and II water-rise stations located beyond the production area Water from the number I pump station is pumped both to the Plant (to two 500 m^3 tanks) and the residential district The number II pump station pumps water from the above-mentioned tanks to the Plant The number I pump station delivers water only to the residential district City water is not supplied to the Plant The number II pump station is not operating

Currently, the Plant is supplied from artisan wells Only one, with the capacity of 10 m^3 per hour, is now operating They plan to restore two others in the nearest future

The sewerage system of the Plant is a free-flow type

4 2 The analysis of energy consumption and costs

Taking into account the current transient period faced by the Plant and the lack of documentation on the Plant's activities for the past few years, the analysis of the energy consumption parameters and costs were made using data from 1993 In spite of the current production decline caused by the drop in market demand, all production facilities are operable and produce goods Data on the design capacity of the workshops, the utilization of their production capacity in 1993 and the planned production output for 1999 is specified below in table 4 2 1

Table 4 2 1 Utilization of Production Capacities

№	Product	Unit	Design capacity	Output in 1993*		Planned amount, 1999	
				Pcs	share, %	pcs	share, %
1	Precast concrete	thsnd m^3	74 0	15 8	21 4	30	40 5
2	Lime-sand brick	million pcs	45 0	7 7	17 1	50 4	112
3	G/F blocks	thsnd m^3	60 0	18 0	30 0	96 0	160
4	Lime for process purposes	thsnd tons	40 0	10 9	27 3	48 0	120
5	Thermal insulation	thsnd m^3	122 0	16 7	13 7	120 0	98
6	Tile	thsnd m^2	120 0	53 8	44 8	120 0	100

Note *"share" means a percentage of the amount of produced goods to the production capacity of process equipment on January 1994

The Plant uses coal (caloricity 6,000-6,200 kCal/kg) coke (caloricity 6,650 kCal/kg), electricity and artisan-well water The Plant pays around 20,000 rubles annually for the use of the four artisan wells, although only one well is currently in operation

Table 4 2 2 provides data on the energy consumption dynamics of the Company in 1993 and 1997 as well as 1999 forecasts

Table 4 2 2 Utilities consumption in 1993, 1997, 1999

Utility	Unit	1993	1997	1999 (plan)
Coal	tons of standard fuel	33,107	no data	12,360
Electric power	MWh	11 228	1,973 4	9,240
City water	thsnd m^3	No data	no data	72
Coke	tons	331	no data	11,520

Table 4 2 3 Heat generation in 1993, 1997, 1999

Utility	Unit	1993	1997	1999 (plan)
Heat energy	GCal	97,826	1,973 4	35,256

The table in Appendix II specifies data on the energy consumption of the Company in 1993

Table 4 2 4 provides data on the total energy consumption and payments in 1993, specified in standard energy equivalents

The utility payments were converted in accordance with current tariffs, including coal - 1,500 rubles/t, water - 1 22 rubles/m^3 (sewage - 0 83 rubles/m^3), ordered capacity - 60 73 rubles per kW, electric power - 0 17

rubles/kWh and reactive power - 0 006 rubles/kVARh

Table 4 2 4 Energy consumption and payments in 1993

Utility	Unit	Consumption	Energy		Price	
			GJ	%	thsnd rubles	%
Coal	ton	37,992	970 333	95 1	5698 8	10 1
Coke	ton	331	9,216	0 9	397 2	75 2
Electric power	MWh	11,228	40,421	4 0	2,662	14 6
City water	thsnd m^3	258	--	--	336	0 1
Total			1,019,970	100	9,094 0	100

Diagrams 4 2 1 and 4 2 2 show the energy consumption structure of the Company in 1993 and payment structure in July 1998

Diagram 4 2 1 Energy consumption structure of the Company in 1993

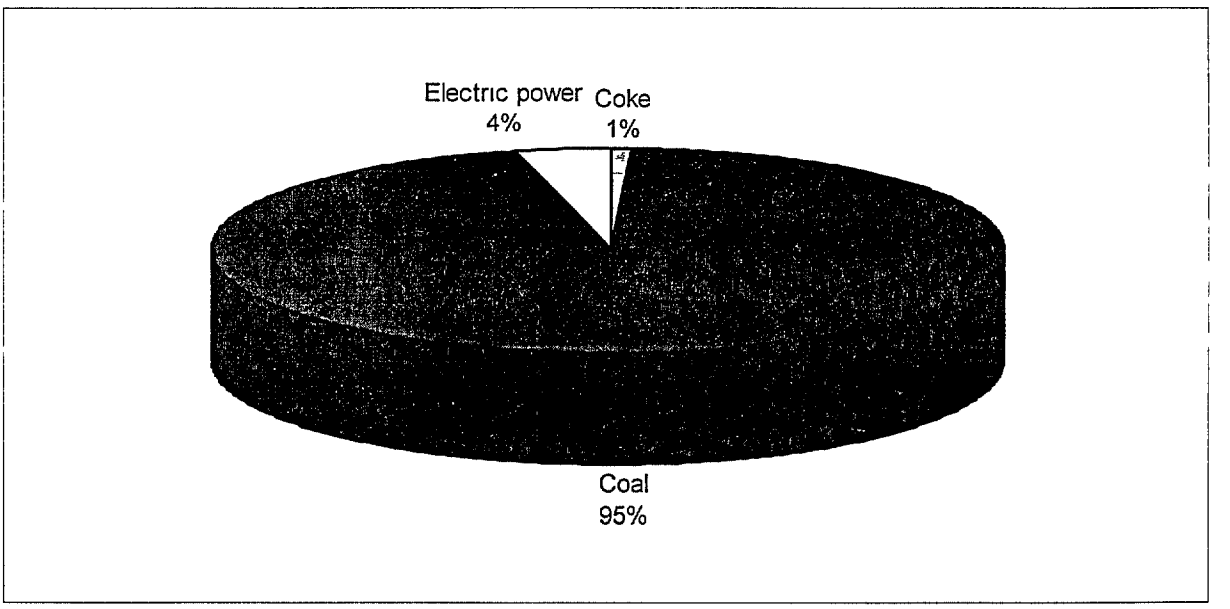
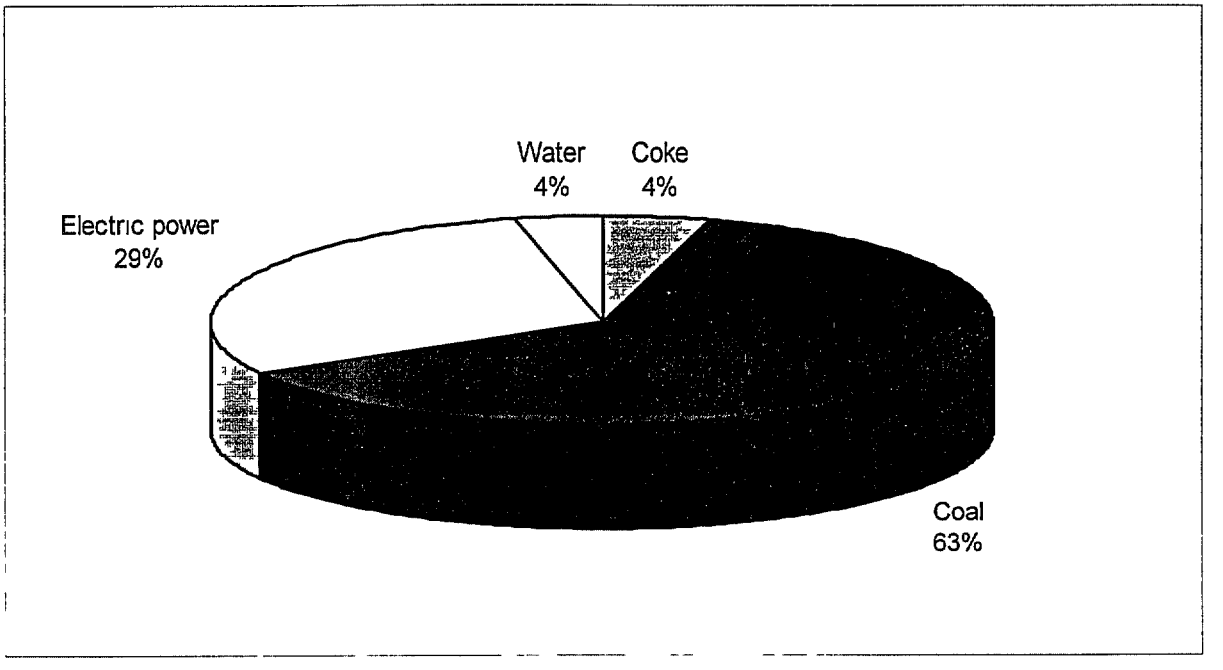


Diagram 4 2 2 Utilities payment structure in 1993



Using a program, developed by the Company, similar diagrams for expected energy consumption have been prepared for 1999

Table 4 2 5 Planned utilities consumption and payments in 1999

Utility	Unit	Consumption	Energy		Price	
			GJ	%	thsnd Rubles	%
Coal	ton	12 360	315 683	47 1	1,854	10 1
Coke	ton	11,520	320 742	47 9	13,824	75 2
Electric power	MWh	9,240	33,264	5 0	2,679 6	14 6
City water	thsnd m^3	72	--	--	20	0 1
Total			669 689	100	18,377 6	100

Diagram 4 2 3 Energy consumption structure of the Company in 1999

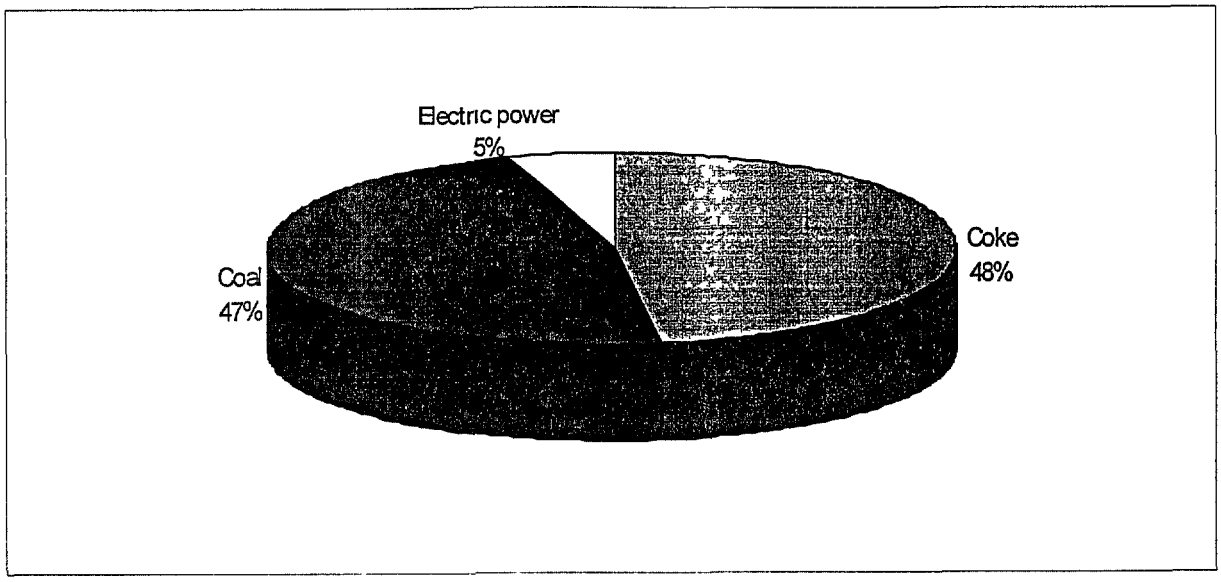
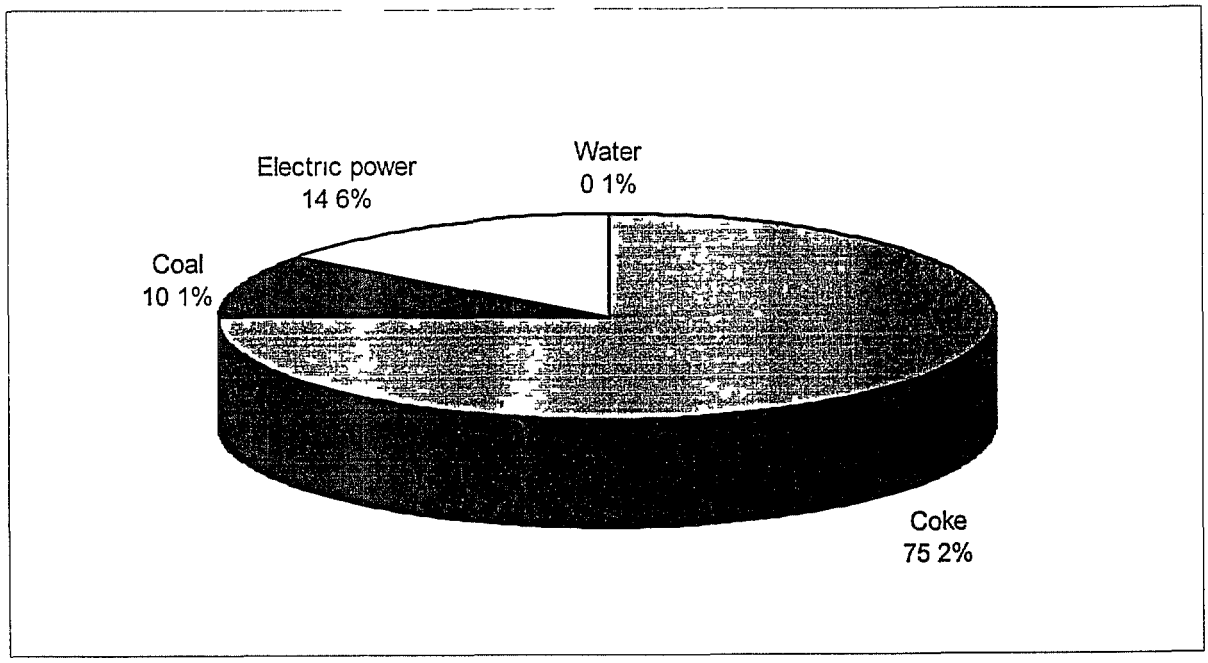


Diagram 4 2 4 Utilities payment structure in 1999



As shown in the diagram above, about 75% of the utility payments are for coke used for lime calcination Taking into account stringent process requirements, no substantial savings of coke in the process units would be expected, therefore, the analysis is focused on coal, electricity and water consumption

Diagram 4 2 5 Process steam consumption by the main workshops of the Company in 1993

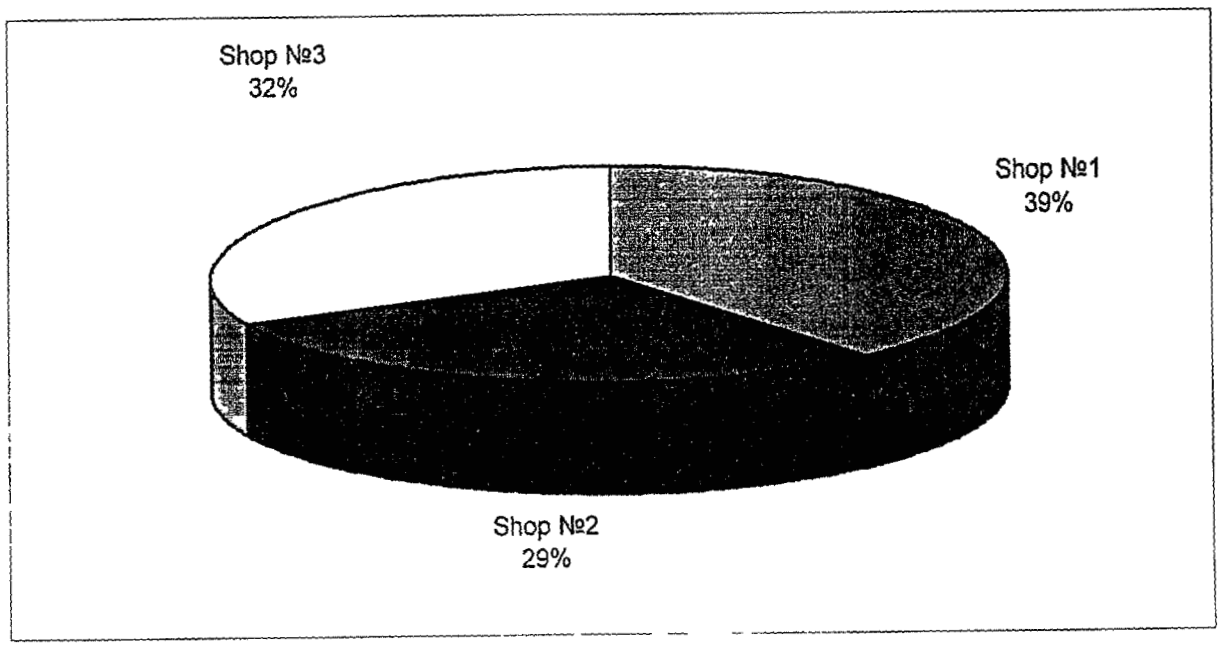


Diagram 4 2 6 Process steam consumption of the main workshops in 1993

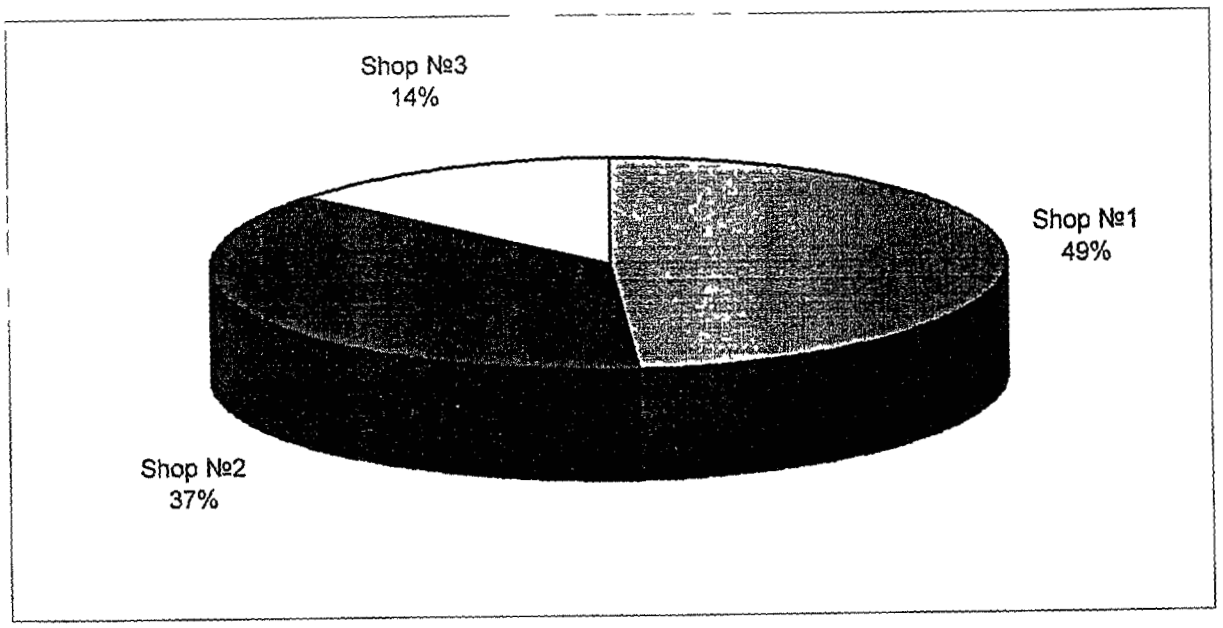


Diagram 4 2 7 Electric power consumption of the main workshops in 1993

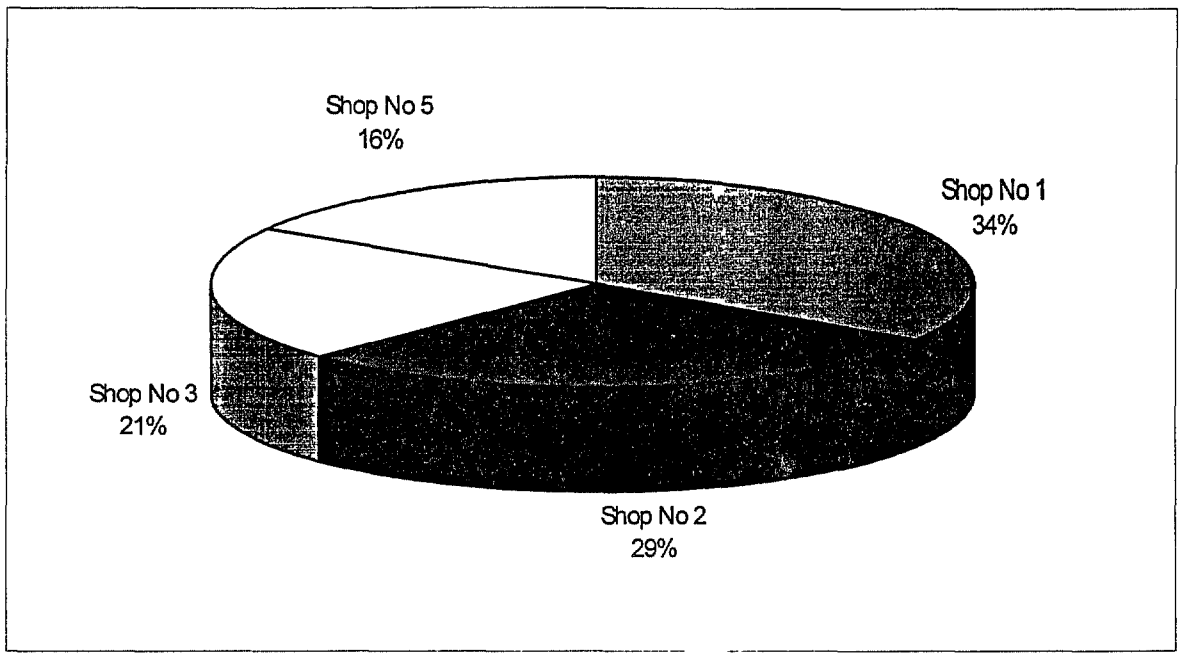


Diagram 4 2 8 Expected process steam consumption of the main workshops 1999

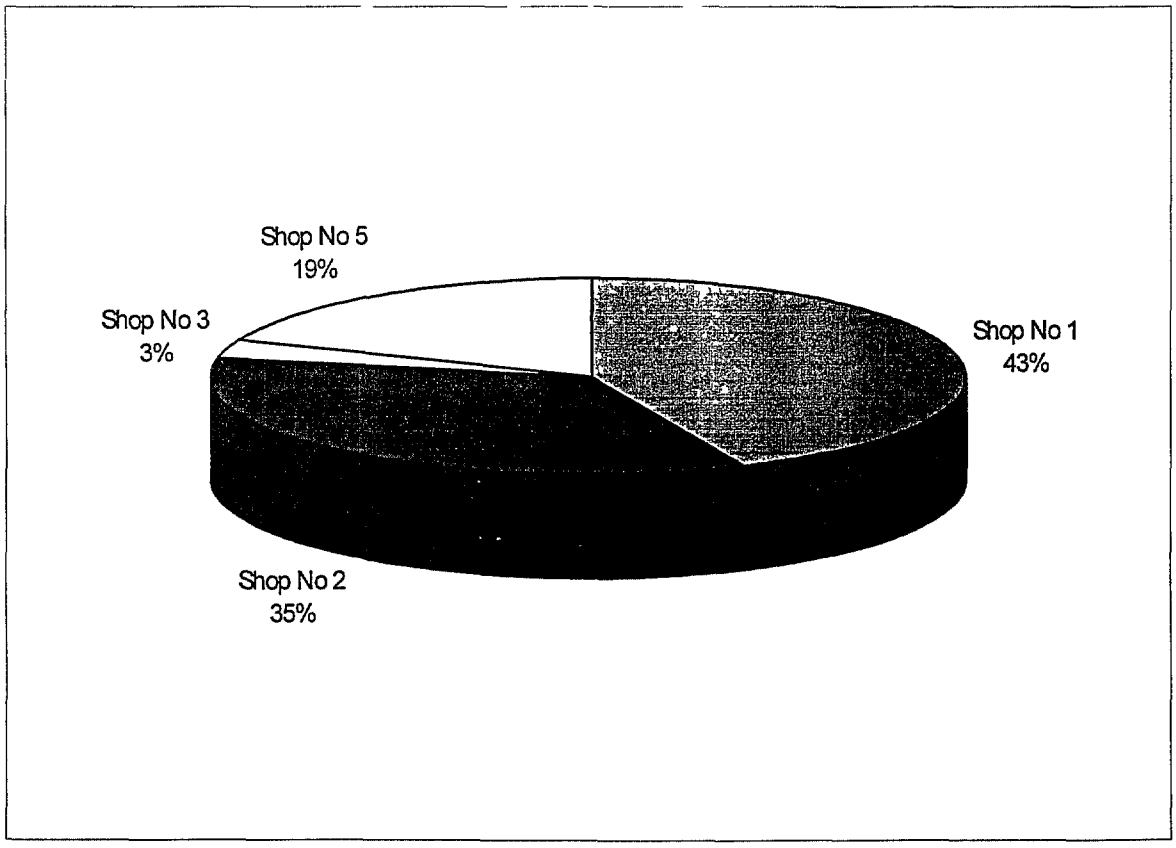


Diagram 4 2 9 Process water consumption structure of the main workshops in 1993

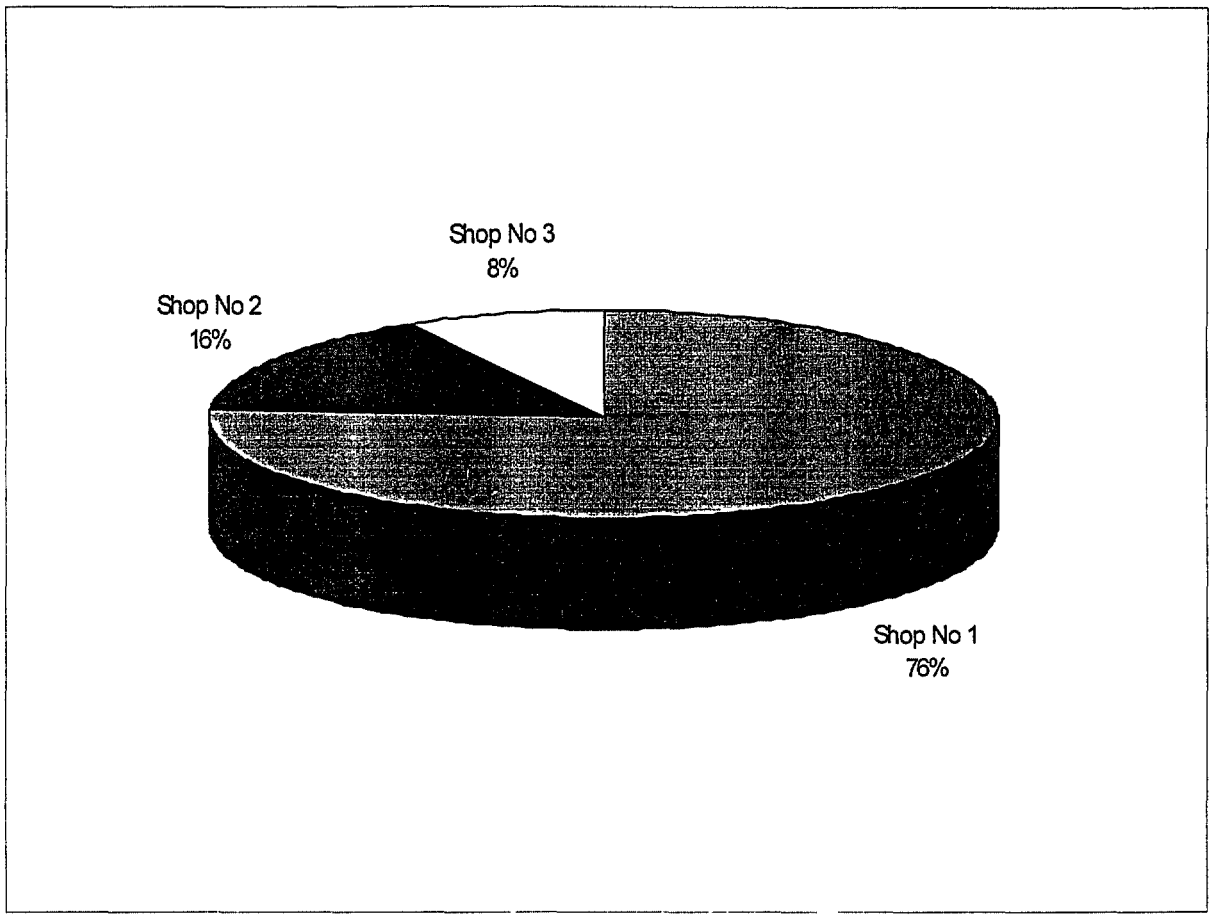


Diagram 4 2 9 Expected process water consumption structure by the main workshops of the Company in 1999

The above mentioned data may be represented in a table format, see table 4 2 6

Table 4 2 6 Utilities consumption structure for process purposes in 1993 and 1999

1993		
Water		
Shop №	m^3	%
Shop №1	10147	0,761558
Shop №2	2109	0,158286
Shop №3	1 068	0,080156
Shop №5	0	0
Total	13 324	1,000

1999 (forecast)		
Water		
Shop №	m^3	%
Shop №1	65748	0,730241
Shop №2	18288	0,203119
Shop №3	6 000	0,06664
Shop №5	0	0
Total	90 036	1,000

Electric power		
Shop №	Mwh	%
Shop №1	901	0,337453
Shop №2	773	0,289513
Shop №3	558	0,208988
Shop №5	438	0,164044
Total	2670	1,000

Electric power		
Shop №	Mwh	%
Shop №1	5066	0,433992
Shop №2	4058	0,347639
Shop №3	336	0,028784
Shop №5	2213	0,189582
Total	11 673	1 000

Steam		
Shop №	GCal	%
Shop №1	12752	0,387634
Shop №2	9624	0,292549
Shop №3	10 521	0,319816
Shop №5	0	0
Total	32 897	1,000

Steam		
Shop №	Gcal	%
Shop №1	69259	0,489348
Shop №2	53074	0,374993
Shop №3	19 200	0,135657
Shop №5	0	0
Total	141 533	1,000

The energy consumption for process purposes in 1991 was as follows water - 5% of the total water consumption by the Company electric power - 24%, heating energy - 85%

No comparison of the utility consumption for process purposes was made due to the uncertain nature of the general energy consumption by the Company, and the possible change of unit energy consumption per unit production

5 ENERGY EFFICIENCY PROGRAMS

5 1 Results of measurements made at the Company

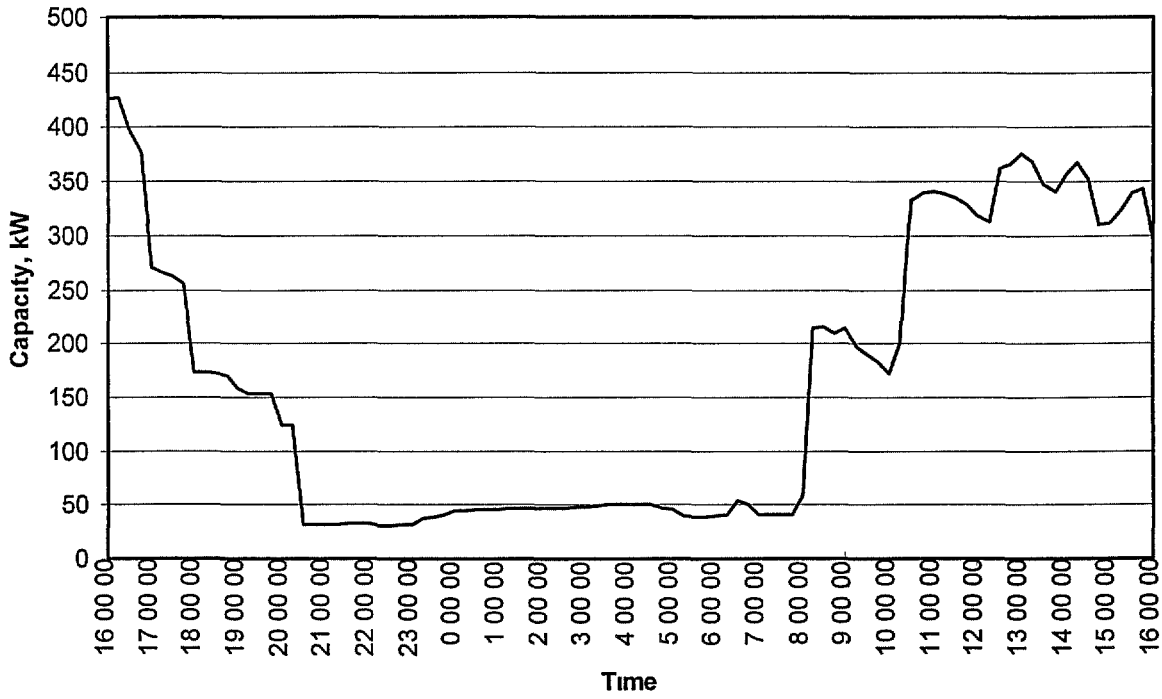
An Elite 4 Energy Logger and a Fluke multi-meter were used for the energy audit The logger was installed on the commercial electric power meter in order to measure the electric consumption of the Company In order to develop the energy structure consumption, the readings of the technical accounting electric power meters installed at the central metering station and the meters measuring electric power supplied to the outside clients were collected on a regular basis

In order to develop the energy consumption curves of individual workshops, the loggers were installed at substation No 2 (lime workshop), substation No 3 (silicate workshop), the feed cable of the administrative building and at the input feeder of the boiler house

The consumption curves are demonstrated in Appendix IV At the same time capacity measurements were recorded by the Elite 4 Logger at most of the electric power end-users with the goal of developing an energy balance for the Company

Fig 5 1 1 shows the electric consumption curve of the Company within the period of July 10-11, 1998 (This curve does not include the outside client See the electric consumption curves in Appendix IV-1, which includes the consumption of the outside clients)

Figure 5 1 1 Aggregate electric power consumption for the Company, including the outside clients, July 10-11, 1998



Only the lime shop (1 oven), the compressor station (1 compressor) and the boiler house (1 boiler) were operating in the normal operation mode Repair teams were working in some workshops The direct production consumption was about 28% of the total daily consumption, including the outside clients (the biggest clients are the garden cooperatives and the asphalt-concrete plant)

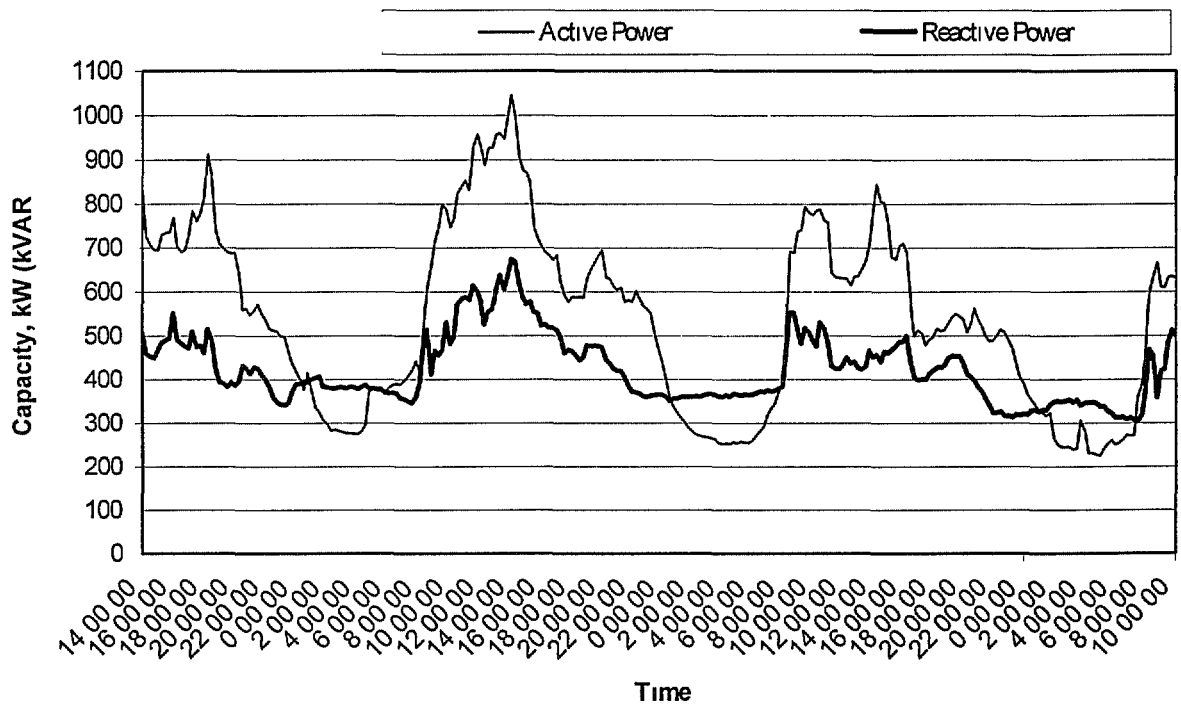
The results of these measurements were used to develop the electric consumption balance for the Company

Table 5 1 1 Energy Balance of the Company

№	End-user	Electric energy consumption, %
1	Lighting system	1 2
2	Boiler house	14 4
3	Technology, including	4 2
4	Air supply	8 2
5	Outside clients	72 0
	TOTAL	100

The large reactive power consumption of the Company is caused by the lack of reactive power capacitors Fig 5 1 1 shows active and reactive power curves for July 10-13

Fig 5 1 1 Consumption of active and reactive power by the Company, including the outside clients



The average daily value for consumed reactive power is 425 kVAR Table 5 1 2 lists measured electric energy consumption for individual end-users

Table 5 1 2 Consumed power measurements of individual end-users

№	Equipment	Installed capacity kW	Consumed power, kW				Cos φ	Load factor
			FN№1	FN№2	FN№3	aggreg		Kз
Boiler house								
1	Smoke Extractor №8	75	6 7	5 9	5 6	18 2	0 61	0 24
2	Blower №8	11	1 4	1 1	2 6	5 1	0 52	0 46
3	PMZ (right)	4 2	0 2	0 7	0 2	1 1	0 4	0 26
4	PMZ (left)	2 2	0 2	0 2	0 9	1 3	0 44	0 59
5	Fire grass	4 5	0 2	0 3	0 2	0 7	0 16	0 16
6	Lighting system	--	0 9	0 7	0 6	2 2	0 87	--
7	Ventilation + lighting	--	0 3	0 2	0 3	0 8	0 53	--
8	Feed pump	55	12 4	11 3	11 8	35 5	0 9	0 65
9	Water pump to the treatment facilities	11	2 0	1 1	1 4	4 5	0 52	0 41
10	Water pump to the deaerator	47	2 7	3 6	3 8	10 1	0 5	0 21
Lime Shop								
1	Blower	30	1 6	3 8	3 0	8 4	0 33	0 28
2	Lime conveyer to shop №2	11	0 6	0 7	0 6	1 9	0 31	0 17
3	Skip hoist	30	3 7	2 8	2 8	9 3	0 59	0 31
Compressor station								
1	Compressor ВП-20/8	125	30	32	31	93	0 87	0 74
2	Recycling water pump of the cooling system	7 5	2 2	2 1	2 4	6 7	0 65	0 89

The low load factor of the electric motors is caused by the fact that most of them are oversize, with their capacity exceeding the actual equipment requirements The lack of money to restore broken electric motors or to replace them with new energy efficient ones may explain this problem

Compressed Air Supply System

For the purpose of this audit the compressed air system was tested to evaluate air leakage The test was carried out in the following manner At the end of the work-shift, when all end-use equipment was shutdown, the pressure in the system was maintained at a level of 5 5 atm The pressure dropped over the test period time The compressors were started and the rated pressure was restored The leakage volume during the test plus the time of pump operation was defined by the time of the pumps operation The compressed air system was also examined as a whole during the test (valves to some production sections were cracked-open)

Table 5 1 3 Compressed Air System Test

Date *21 07 98*
Time *14 30*

№	System section	Test time min	Pressure drop in the system atm	Operation time of the compressor Min	Leakage volume	
					m^3	%*
1	The System as a whole	5'45''	1 4	16'45''	14 9	74 5

Note * - the percentage of leakage volume was defined as follows the ratio of leakage, m^3 (335) to the total air consumption (450 m^3) during the test time at the rated compressor capacity (20 m^3/min)

During the visual inspection of the compressed air system, air leaks were detected in relief valves installed on air tanks and valves on the end-use equipment

A number of water and air temperature measurements at the input and output of the intermediary and end air-coolers were made to evaluate the performance of the water cooling system The air pressure of the system was 5 5 atm The 103VP-20/8 compressor was in operation at that time

Air temperature after number I Stage		- 155°C
	After intermediary cooler	- 71°C
Water temperature	Before intermediary cooler	- 43°C
	After intermediary cooler	- 54°C
Air temperature after the compressor		- 109°C
	After the end cooler	- 90°C
Water temperature	Before intermediary cooler	- 42°C
	After intermediary cooler	- 96°C

It should be noted that the compressors consume a large amount of oil (about 10 liters during 12 hours of operation)

Heating system

Heating system and hot water supply

The heating and hot water supply systems are currently under reconstruction and, therefore, no measurements were taken The condition of the systems, their future development and detected shortcomings are described in Paragraph 4 1

Boiler house

The boiler house is the only user of coal at the enterprise

During the energy audit, the only boiler in proper working order was steam boiler # 8, which had been in operation all through the heating season At the present time the boiler supplies steam to the silicate shop for the periodical steaming of the autoclaves A visual inspection demonstrated that the boiler's condition was unsatisfactory, which was proved by our tests

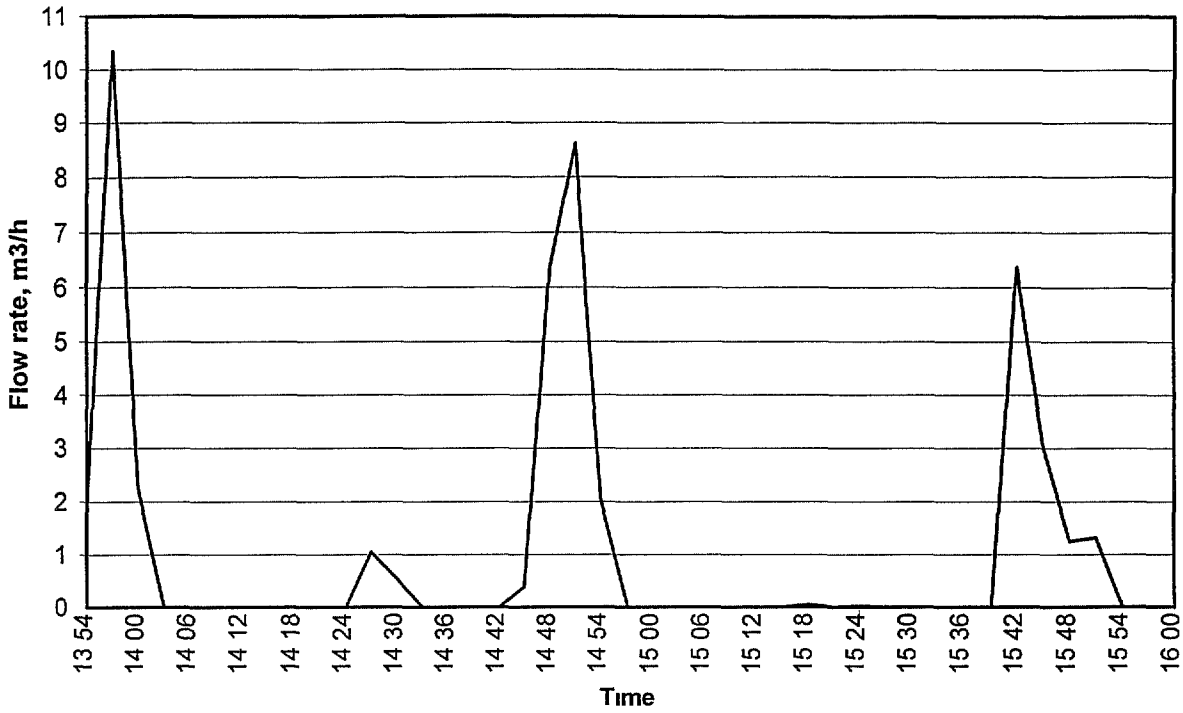
The tests included measuring the temperature and the composition of gas combustion products before the economizer and before the smoke exhauster on boiler # 8 Boiler #8 was put into operation for the purposes of this test, because there was no demand requirement warranting operation The measuring instrument was a BACHARAH electronic analyzer

To measure the consumption of feed water for the boiler, a Panametrics ultrasonic flowmeter was used The surface temperature of different boiler elements, air ducts and pipelines, including steam pipes, was measured with a Raynger infrared pyrometer Because of the absence of technological load, the boiler was tested in the minimum load operating conditions The test results and the calculated heat losses of the boiler are given in Attachment VI

On the basis of the measurements taken, the following conclusions can be made

- There are high air inflows along the boiler path (480% before the economizer and 735% after the economizer), due to which heat losses with flue gases amount to 35% The obtained values of air inflows are much higher than the values indicated in the boiler's specifications (54% and 85% respectively) A decrease of air inflows down to the standard values will increase the boiler's efficiency by 24 4% and save 3015 0 tons of coal (or 452 376 rubles),
- The temperature of feed water at the inlet and the outlet of the deaerator was 45° and 75° respectively,
- A visual inspection of the pipes in the boiler house demonstrated the total absence of insulation on the feed water duct and incomplete insulation of the steam line between the boiler house and the silicate shop (see Attachment V),
- The average rate of feed water flow during the measurements was 1 3 tons per hour (see Figure 5 1 2),
- A substantial part of the boiler settings are damaged, the temperatures of some elements of the boiler are 150-300°C, and those of the economizer – 90-13°C

Fig 5 1 2 Feed water consumption by boiler №8



5 2 Potential energy efficiency projects

The inspection and instrumental measurements have revealed possibilities for improving the Company's energy efficiency

Due to the lack of revenues from the sale of the Company's products, the main objective of management was to put technological and energy equipment in operation as soon as possible, even if the schemes and modes of operation were not very efficient

The main departments (the foamed concrete and reinforced concrete shops) are not in operation yet The silicate shop does not work on a regular basis On line in the boiler house is just one steam, one feeding pump, etc Sometimes, just to start the equipment, any available motor drive that works is used, even if its capacity is not adequate So, due to the insufficient amount of measurements and incomplete data on the characteristics of the installed equipment, many of the proposed measures are not presented as projects but are just estimated as to their energy efficiency

Electric power supply

The Company pays the electric bills on a contractual basis for electric power supplied by Novosibirsk Energo for the Plant and the connected outside clients If a system of accounting for the power consumption of the individual sections of the Company and the outside clients were set up it would be possible to provide a full picture of the overall electric power consumption of the Company This information is especially important when creating contracts with the utility company It would allow for a drop of electric power costs to a minimum by means of distributing electric loads among various divisions of the Company It also allows for the appropriate selection of reactive power capacitors and the location for their installation, etc The introduction of such a system would require the installation of missing meters and the verification of existing meters

In addition, such a system would make it easier to motivate the maintenance personnel of the Company to save electric power

As mentioned above in Clause 5 1 the Company does not have any reactive power capacitors The Company pays for the consumed reactive power, therefore it could be recommended that they install capacitors A reduction of losses within the energy system would be an additional positive impact of this program The installation of a 100 kVAR capacitor at the central distribution station would allow for a reactive power drop of 876,000 kVARh and a saving of about 5,300 ($815)

Lighting system

Presently, the lighting system in the workshops is not operating, so the electrical consumption of the lighting system is low However, considering the large installed capacity of the lighting equipment, it is necessary to pay attention to the efficient use of this system, when it is put into operation The lighting system of the workshops should be sectioned Appropriate controls and actions relating to the use of the lighting system will result in a large reduction of electricity costs

Compressed air system

Presently, about 30% of the total amount of the electric power consumed by the Company (excluding outside clients) is consumed by the air compressor system, although the amount of compressed air required by the workshops is rather small This large power consumption is caused by the continuous operation of the compressor, with the capacity of 20 m^3/min, during the 12-hour shift Due to the fact that the compressor is not equipped with automatic capacity adjustment, excessive air is periodically discharged from the system into the atmosphere The elimination of air leaks detected during the inspection could be effective only if a new compressor is installed The inefficient operation of the compressors is aggravated by its high maintenance cost (the cost of oil replacement is about 14,500 rubles per year)

Several variants may be recommended in order to increase the efficiency of the compressed air system The first variant - to make major repairs to the smaller compressor, with the capacity of 12 m^3/min, and put it into operation (provided that all leaks in the air system are eliminated) The second variant - to buy a new compressor with a wide range of capacity adjustment and a smaller capacity of 6-10 m^3/min When the Plant is restored to its normal production capacity, it is recommended they consider a decentralized air supply system Smaller compressors that are installed directly in the workshops would handle the need of compressed air for individual sections In this case, the existing compressors may supply the large end-users of compressed air, for example, pneumatic transport systems Such an approach would prevent air leakage in the compressed air system and would make it possible to match the maximum operation of the compressors to the end-users of compressed air

Heating system

A detailed description of the condition of the heating and hot water supply systems is given in Paragraph 4 1 above When rehabilitating the systems, emphasis should be put on the insulation of the pipelines, because only 20-25% of them are in a satisfactory state Our calculations show that insulation costs including assembly works will be repaid within 3-6 months, depending on what insulation and coating materials are used It is advisable to coat the existing condensate storage tanks and condensate lines with an insulation material

The hot water boilers installed in each of the shops are heated with steam The steam flow rate and the temperature of hot water are controlled manually by the personnel, which may lead to excessive heat consumption Since automatic water temperature controls cannot be installed for the time being, more control is needed to prevent water overheating and excessive steam consumption Instead of steam, it is advisable to use steam condensate after the steam registers of the heating system If the condensate cannot be returned to the boiler house, hot water (condensate) should be used for technological purposes

Boiler house

The installed boilers are currently in an unsatisfactory working condition Boilers No 4, 6 and 7 are not likely to be reconditioned Boilers No 5 and 2 will be repaired soon There is one new boiler - No 3, which needs to be brick-lined But the Company's management does not plan to repair or put boiler No 3 into operation in the near future

Boiler No 8 will be shut down for maintenance in April 1999 The boiler uses raw water The water treatment system does not work because of the absence of salt Our tests demonstrated unsatisfactory conditions in the boiler substantial air inflows, great heat losses into the atmosphere and, consequently, low efficiency – 55 5% (see Project 7) The actual efficiency is even lower, because the calculations ignored combustible losses that may very significant (up to 10-15%) because it is impossible to change the speed of the boiler grates (none of the boilers has four-speed motors) The coal crusher is out of service A decrease of combustible losses down to the normative values will save at least 2-2 5 thousand tons of coal a year (or about 300-375 thousand rubles)

5 3 Recommended energy efficiency projects

Project No 1

Use vented-steam from the deaerator to heat the treated water

1 <u>Savings</u>

Annual coal	980 tons - 147 0 thousand rubles ($22,33)
Total savings	147 0 thousand rubles ($22,33)

2 <u>Expenses</u>

Total costs	none

3 <u>Simple payback period</u>

Recommendations
Use the vented-steam from the deaerator to heat the treated water

Description
It is proposed to use the existing heat exchanger to heat the treated water by vented-steam from the deaerator

Expected savings
Under current coal tariffs the saving of 980 0 tons of coal is equivalent to 147 0 thousand rubles ($22,33)

Required investments
The recommended project does not require any investment

Payback period
A simple payback period is equal to zero

Implementation period
This project can be implemented after the normal operation of the deaerator is restored by heating the feed water to the required temperature of 102-104C and repairing the heat exchanger

Technical risks associated with the change of quality and/or quantity of output production
There are no risks for this project

Initial data and results of estimations
Presently, the deaerator is operating with a water temperature of 60-75C, therefore it does not serve its technical purpose - to deaerate the feed water Once the deaerator is repaired, it is necessary to use vented-steam energy in the heat exchanger in order to heat the feed water The capacity of the boiler house is equal to 20-25 tons of steam per hour, so the amount of generated steam should be more than 1 t/hour The use of the vented-steam energy to heat the treated water would allow a saving of about 5,89 0 GCal per year The design efficiency of the heat exchanger was assumed to be 0 9 of the boilers - 0 75 Thus, fuel savings should be 980 0 tons of coal with the caloricity of 6,000 kCal/t or 147 0 thousand rubles $22,33)

Project No 2

Install reactive power capacitors

1 **Savings**

Annual savings	5,300 thousand rubles ($815)
Total savings	147,0 thousand rubles ($23,330)

2 **Expenses (including V A T)**

Total 1,500 rubles ($238,1)

3 **Simple payback period**

Recommendations
Install reactive power capacitors at the SDP for reactive power compensation

Description
It is proposed to install reactive power capacitors in order to save money and to improve quality of electricity in the power system through reduced reactive power consumption

Expected savings
Under the current reactive power tariffs, a reduction in reactive power consumption by 876,000 kVAr/hour will save about 5,300 rubles ($815)

Required investments
The required investments are estimated at 1,500 rubles ($238 1)

Payback period
A simple payback period is equal to 4 months The scale of the project does not require the calculation of the Internal Return Rate (IRR)

Implementation period
This project can be implemented immediately

Technical risks associated with the change of quality and/or quantity of output production
There are no risks for this project

Initial data and results of estimations
According to the measurements taken, the average reactive power consumption is 425 kVAr The installation of a 100-kVAr reactive power capacitor will reduce reactive power consumption by 876,000 kVAr/hour, thus saving nearly 5,300 rubles ($815)

Project No 3

Insulate non-insulated pipes

1 **Savings**

Annual coal	395 tons - 59,250 thousand rubles ($9,405)
Total savings	59,250 thousand rubles ($9,405)

2 **Expenses (including V A T)**

Mineral wool	5,256 rubles ($835)
Asphalt paper	600 rubles ($95)
Zinc plated sheet	1,200 rubles ($190)
Insulating works	4 234 rubles ($672)
Total	11,290 rubles ($1,792)

3 **Simple payback period**

Recommendations
Insulate non-insulated pipe sections in the boiler house and the pipeline to the silicate shop

Description
It is proposed to install appropriate insulation in order to reduce heat losses through non-insulated pipes and valves of the steam supply systems

Expected savings
Under current coal tariffs the saving of 395 toms of coal is equivalent to 59,250 thousand rubles ($9,405)

Required investments
The insulation of the non-insulated pipe sections with the total length of 280 m would require about 8 5 m^3 of mineral wool, 200 m^2 of asphalt paper and about 300 kg of zinc-coated sheets The estimated price of the insulating materials (mineral wool - 480 rubles/m^3, asphalt paper - 3 rubles/m^2, 4,000 rubles/ton of zinc plated sheets) and insulating works (assuming a factor of 0 6 of the total price of material costs) is about 11,290 rubles ($1,792), including V A T

Payback period
A simple payback period is equal to 3 months The scale of the project does not require the calculation of the Internal Return Rate (IRR)

Implementation period
This project can be implemented immediately

Technical risks associated with the change of quality and/or quantity of output production
There are no risks for this project

Initial data and results of estimations
The results of measurements of length, diameter and temperature of the surface of non-insulated pipes in the boiler house and the pipeline to the silicate shop were used as initial data The total heat losses are equal to 309 5 kW The economic thickness of insulation for the given type of pipelines is in the range of 60 mm After insulating the pipes, the total heat losses through the insulated pipelines should amount to about 16 kW Considering the operation of separate systems the annual heat saving would be 2,101,404 kWh

Thus, the insulation of the pipelines would allow a saving of about 395 tons of coal - 59,250 rubles ($9,405) The design efficiency was assumed to be 75% All heat loss calculations through non-insulated pipes and the evaluation of the economic insulation thickness was made according to reference tables

Project No 4

Re-use of steam from the pressure-chambers in the Silicate Shop

1 <u>Savings</u>

Annual savings	300 tons	45,0 thousand rubles ($7,140)
Total savings		45,0 thousand rubles ($7,140)

2 <u>Expenses (including V A T)</u>

Total	1,500 rubles ($238,0)

3 <u>Simple payback period</u>

Recommendations
Re-use the steam from one pressure-chamber that has completed its technological cycle, redirecting it to another chamber that is ready for operation

Description
In order to reduce heat losses from steam venting, it is proposed to use the steam from the pressure-chambers that have completed their technological cycle, redirecting it to a loaded pressure-chamber that is ready for steaming

Expected savings
Under the current coal prices, the saving of 300 tons of coal is equal to 45,0 thousand rubles ($7,140)

Required investments
To restore the system of re-using the steam from pressure-chambers that have completed their technological cycle, the system needs to be revised Some of the steam valves will have to be replaced, and the sequence of steam redirection operations needs to be adjusted The required investments are estimated at 15,000 rubles ($2,380)

Payback period
A simple payback period is equal to 4 months The scale of the project does not require the calculation of the Internal Return Rate (IRR)

Implementation period
This project can be implemented during the preparation of the Silicate Shop for operation

Technical risks associated with the change of quality and/or quantity of output production
There are no risks for this project

Initial data and results of estimations
Experimental data on the functioning of the steam re-use system in the Silicate Shop were used as the input data for this project Before the steam redirection begins, a heated pressure-chamber completing its operation cycle contains about 280 kg of steam and its pressure is 8 atm The experiments show that as a result of the redirection, the steam pressure in both pressure-chambers is equalized at about 1 7 atm According to the calculations, the second pressure-chamber receives 205 kg of steam, with 130 kg of steam condensed, releasing 286 MJ of heat In this case, an annual saving of live steam will be nearly 750 tons, which is equivalent to 300 tons of coal or 45,0 thousand rubles ($7,140) The calculations were based on the following assumptions design efficiency – 75%, the number of steam redirection cycles a day – 10

Project No 5

Insulate the pressure-chambers in the Silicate shop

1 Savings

Annual coal	950 tons - 142,5 thousand rubles ($22,600)
Total savings	142,5 thousand rubles ($22,600)

2 Expenses (including V A T)

Mineral wool	2 160 rubles ($342)
Zinc plated sheet	14,000 rubles ($2,222)
Insulating works	9,696 rubles ($1,538)
Total	25,856 rubles ($4,102)

3 Simple payback period

Recommendations
Insulate the pressure-chambers in the silicate shop

Description
It is proposed to install appropriate insulation in order to reduce heat losses through non-insulated sections of the pressure-chambers

Expected savings
Under current coal tariffs the saving of 950 tons of coal is equivalent to 142,5 thousand rubles ($22,600)

Required investments
The insulation of the non-insulated pressure chamber sections would require about 4 5 m^3 of mineral wool and about 3500 kg of zinc-coated sheets The estimated price of the insulating materials (mineral wool - 480 rubles/m^3, asphalt paper and 4,000 rubles/ton of zinc plated sheets) and insulating works (assuming a factor of 0 6 of the total price of material costs) is about 25,856 rubles ($4,102), including V A T

Payback period
A simple payback period is equal to 3 months The scale of the project does not require the calculation of the Internal Return Rate (IRR)

Implementation period
This project can be implemented immediately

Technical risks associated with the change of quality and/or quantity of output production
There are no risks for this project

Initial data and results of estimations
The results of measurements of length, diameter and temperature of the surface of non-insulated areas of the pressure chambers in the silicate shop were used as initial data The total heat losses are equal to 1223 kW The economic thickness of insulation for the given type of pipelines is in the range of 50 mm After insulating, the total heat losses through the insulated pipelines should amount to about 73 4 kW Considering the operation of the pressure chambers according to the planned production targets, the annual heat saving 5,037,000 kWh

Thus, the insulation of the pressure chambers would allow a saving of about 950 tons of coal - 142,5 thousand rubles ($22,600) The design efficiency was assumed to be 75% All heat loss calculations through non-insulated pipes and the evaluation of the economic insulation thickness was made according to reference tables

Project No 6

Insulate the pressure-chambers in the Foamed Concrete Shop

1 Savings

Annual coal savings	1480 tons	222 65 thousand rubles ($35,340)
Total savings		222 65 thousand rubles ($35,340)

2 Expenses (including V A T)

Mineral wool	3,600 rubles ($571,4)
Zinc-plated sheet	22,000 rubles ($3,492)
Insulating works	15,360 rubles ($2,438)
Total	40,960 rubles ($6,500)

3 Simple payback period

Recommendations
Insulate the non-insulated parts of the pressure-chambers in the Foamed Concrete Shop

Description
It is proposed to install appropriate insulation in order to reduce heat losses through the non-insulated parts of the pressure-chambers

Expected savings
Under the current tariffs, the saving of 1480 tons of coal is equal to 222 65 thousand rubles ($35,340)

Required investments
The insulation of the pressure-chambers will require about 7 5 m^3 of mineral wool and nearly 5,500 kg of zinc-plated sheets The estimated cost of insulating materials (mineral wool – 480 rub/m^3, zinc-plated sheets - 4,000 rub/ton) and insulating works is about 40,960 rubles ($6,500), including VAT

Payback period
A simple payback period is equal to 3 months The scale of the project does not require the calculation of the Internal Return Rate (IRR)

Implementation period
This project can be implemented during the preparation of the Foamed Concrete Shop for operation

Technical risks associated with the change of quality and/or quantity of output production
There are no risks for this project

Initial data and results of estimations
The initial data included the size and temperature of the non-insulated parts of the pressure-chambers in the Foamed Concrete Shop The total heat losses are 1,223 kW The economic thickness for the given type of pipelines is 50 mm After the insulation, the total heat losses through the insulated pipelines will amount to about 73 4 kW The annual heat saving will be 7,870,360 kWh

Thus, the insulation will make it possible to save nearly 1,480 tons of coal or, in terms of money, 222 65 thousand rubles ($35,340) The design efficiency is assumed to be 75% The calculations of heat losses through the non-insulated parts and the evaluation of the economic insulation thickness were based on reference tables

Project No 7

Decreasing air inflows in boiler No 8

1 **Savings**

Annual savings	3,015 0 tons	452,376 thousand rubles ($71,805)
Total savings		452,376 0 thousand rubles ($71,805)

2 **Expenses (including V A T)**

Repair and reconditioning works	100,000 rubles ($15,873)
Total	100,000 rubles ($15,873)

3 **Simple payback period**

Recommendations
Decrease air inflows in the stack gas duct

Description
It is proposed to improve the gas-tightness of the boilers by means of restoring the setting, closing the slots, sealing the hatches and removing the cracks

Expected savings
Under the current coal prices, the saving of 3,015 tons of coal is equal to 452,376 thousand rubles ($71,805)

Required investments
The estimated cost of reconditioning works is about 100,000 rubles ($15,873), including VAT

Payback period
A simple payback period is equal to 3 months The scale of the project does not require the calculation of the Internal Return Rate (IRR)

Implementation period
This project can be implemented immediately during the annual repair and reconditioning period

Technical risks associated with the change of quality and/or quantity of output production
There are no risks for this project

Initial data and results of estimations
The measurements of Boiler 8 have revealed extremely great air inflows of 735%, which increases heat losses with flue gasses up to 35% Decreasing air inflows down to the values indicated in the specifications of the boiler (86%) would increase the boiler's efficiency by 24 4% The total annual fuel savings, based on the projected output, would be 3,015 tons or 452,376 rubles ($ 71,805) The cost of repair and reconditioning works was assumed to be equal to 50% of the boiler's cost, including VAT

APPENDIX

APPENDIX I PRODUCTION OUTPUT OF THE COMPANY IN 1993 AND ENERGY CONSUMPTION FOR PROCESS NEEDS

	Production	Unit	Jan	Feb	March	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Per year
1	Reinforced foamed concrete	m^3	0	0	0	0	228	210	194	199	205	254	304	416	2010
	Electricity	KWh	0	0	0	0	6384	5901	5418	5678	5740	7126	8512	11676	56435
	Water	m^3	0	0	0	0	44	33	22	29	37	68	99	136	468
	Steam	Gcal	0	0	0	0	130	105	80	141	202	184	166	306	1314
2	Gas-foamed concrete blocks	m^3	2436	2336	1788	2239	264	1239	1215	1216	1216	951	687	1049	16636
	Electricity	KWh	75294	72190	60613	75902	42849	42018	41188	41205	41222	32255	23289	35561	583586
	Water	m^3	561	538	411	515	291	285	280	284	289	223	158	241	4076
	Steam	Gcal	816	783	651	807	424	427	431	461	482	356	230	372	6240
3	Thermal insulation	m^3	1531	1946	1121	2470	1693	1990	2288	1513	739	735	732	907	17665
	Electricity	KWh	19977	25385	16927	37297	25564	30056	34549	23246	11944	11498	11053	13696	261192
	Water	m^3	482	613	353	778	533	627	721	486	252	241	231	286	5603
	Steam	Gcal	473	602	333	662	526	598	671	424	222	213	204	270	5198
4	Brick	Thousand pcs	958	1019	1082	615	750	729	708	652	596	513	430	321	8373
	Electricity	kWh	68840	73157	82989	47170	57525	55937	54350	50031	45713	39355	32981	24621	632669
	Water	m^3	112	120	129	116	96	91	87	113	140	117	95	71	1287
	Steam	GCal	681	724	765	435	527	504	481	461	441	374	307	201	5901
5	Tile	thousand pcs	184	197	164	138	170	166	162	149	136	137	140	68	1811
	Electricity	kWh	14204	15208	12661	10654	13124	12815	12506	11502	10499	10653	10808	5250	139884
	Water	m^3	9	10	64	65	69	61	54	92	130	112	94	62	822
	Steam	GCal	379	406	338	293	344	345	346	309	272	275	276	140	3723
6	Reinforced concrete	m^3	1589	1702	2012	1777	1487	1318	1150	851	552	959	1167	975	15539
	Electricity	kWh	53830	57634	74042	65394	54722	48530	42338	33447	24556	30313	36070	36778	557654
	Water	m^3	116	125	173	150	99	67	36	61	87	58	30	66	1068
	Steam	GCal	1047	1121	1371	1237	1006	917	829	674	519	689	859	252	10521
7	Lime	tons	1005	1077	1007	1016	755	877	999	926	854	750	647	617	10530
	Electric power	kWh	38081	40772	42797	43180	32087	37272	42457	39376	36295	31896	27497	26222	437932
TOTAL, process needs															
	Electricity	kWh	270226	284346	290029	279597	232255	232529	232806	204485	175969	163096	150210	153804	2669352
	Water	m^3	1280	1406	1130	1624	1132	1164	1200	1065	935	819	707	862	13324
	Steam	GCal	3396	3636	3458	3434	2957	2896	2838	2470	2138	2091	2042	1541	32897

APPENDIX II UTILITIES CONSUMPTION of THE COMPANY IN 1993

	Utility	Unit	Jan	Feb	Mrch	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Per year
1	Coal	standard fuel ton	3920	3858	3561	3471	2362	2111	2091	1970	2195	2727	2262	2579	**33107**
	tariff	rub/t	150	150	150	150	150	150	150	150	150	150	150	150	
	paid for 1993	thsnd rub	674,75	664,08	612,96	597,47	406,57	363,37	359,93	339,10	377,83	469,40	389,36	443,93	**5698,75**
	Coke	ton	34,0	36,0	35,5	34,0	30,5	28,9	28,0	24,0	21,3	21,9	20,4	16,5	**331,0**
	tariff	rub/t	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	
	paid for 1993	thsnd rub	40,80	43,20	42,60	40,80	36,60	34,68	33,60	28,80	25,56	26,28	24,48	19,80	**397,20**
2	Electric power														
	ordered capacity	kW	1100	1100	1000	1000	1000	1000	1000	1000	1000	1000	1100	1100	**12400**
	tariff	rub/kW	60,730	60,730	60 730	60,730	60 730	60,730	60,730	60,730	60,730	60,730	60,730	60,730	
	paid for 1993	thsnd rub	66,80	66,80	60 73	60,73	60 73	60,73	60,73	60,73	60,73	60,73	66 80	66,80	**753,05**
	electric power	MWh	960,00	920 00	930 00	860,00	750 00	1380 00	1480 00	1380 00	770,00	690 00	560 00	548,00	**11228,000**
	tariff	rub/kWh	0,170	0 170	0 170	0 170	0,170	0,170	0 170	0,170	0,170	0,170	0,170	0,170	
	paid for 1993	thsnd rub	163,20	156 40	158,10	146,20	127,50	234 60	251,60	234,60	130,90	117,30	95,20	93,16	**1908,76**
	Total	rub	230 00	223,20	218 83	206 93	188 23	295 33	312,33	295 33	191 63	178,03	162,00	159 96	**2661,812**
3	City water supply														
	consumption	m^3	16380	21406	21130	24139	23132	23164	24200	23065	23905	15919	20707	20862	**258009**
	tariff	rub/m^3	1,220	1,220	1,220	1,220	1 220	1,220	1,220	1 220	1,220	1,220	1,220	1 220	
	paid for 1993	thsnd rub	20,0	26,1	25,8	29,4	28 2	28 3	29,5	28,1	29,2	19,4	25,3	25,5	**314,77**
	sewage	m^3	1638	2141	2113	2414	2313	2316	2420	2307	2391	1592	2071	2086	**25801**
	tariff	rub/m^3	0,830	0,830	0,830	0,830	0,830	0,830	0,830	0,830	0,830	0,830	0,830	0,830	
	paid for 1993	thsnd rub	1,36	1,78	1,75	2,00	1,92	1,92	2,01	1,91	1,98	1,32	1,72	1,73	**21,41**
	Total	thsnd rub	21,34	27,89	27,53	31,45	30,14	30,18	31,53	30,05	31,15	20,74	26,98	27,18	**336,19**

APPENDIX III HEAT ENERGY GENERATION Of THE COMPANY IN 1993

№	Utility	Unit	Jan	Feb	Mrch	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Per year
1	**Heat energy, including**	Gcal	16720	15100 0	15080 0	12810	9230,0	15280 0	15280 0	15280 0	8770,0	9370,0	6710,0	8129,0	147759,0
	process needs	Gcal	8540,0	7350 0	8050,0	6030,0	5030 0	11780 0	11780 0	11780,0	4560,0	3500,0	2200,0	2230 0	82830,0
	for heating, HWS	Gcal	2560	2400,0	2460 0	2350,0	0,0	0,0	0,0	0,0	960,0	1530,0	1460,0	1276,0	14996,0
	to outside clients	Gcal	5620,0	5350,0	4570,0	4430,0	4200,0	3500,0	3500,0	3500,0	3250,0	4340,0	3050,0	4623,0	49933,0

APPENDIX IV DAILY ELECTRIC POWER CONSUMPTION CURVES of THE MAIN CONSUMERS OF THE COMPANY

Fig IV-1 Total electric power consumption of the Company (including the outside clients, except for the residential district), July 10-11, 1998

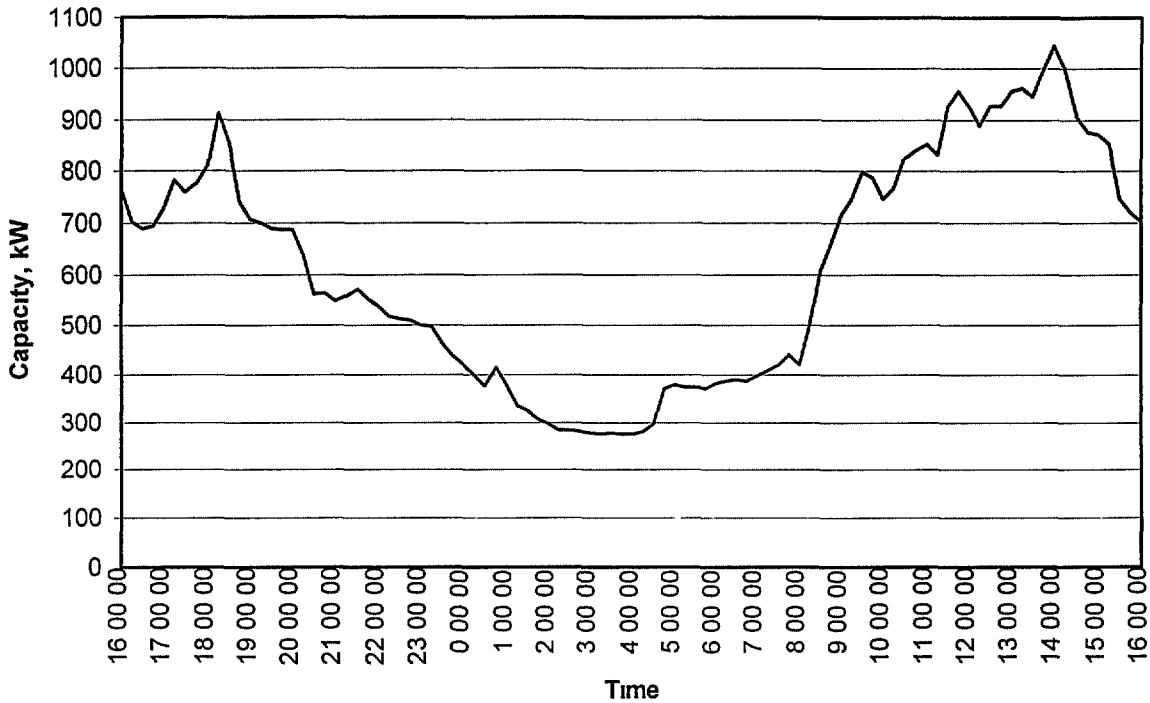


Fig IV-2 Electric power consumption of the outside clients (garden cooperatives), July 10-11, 1998

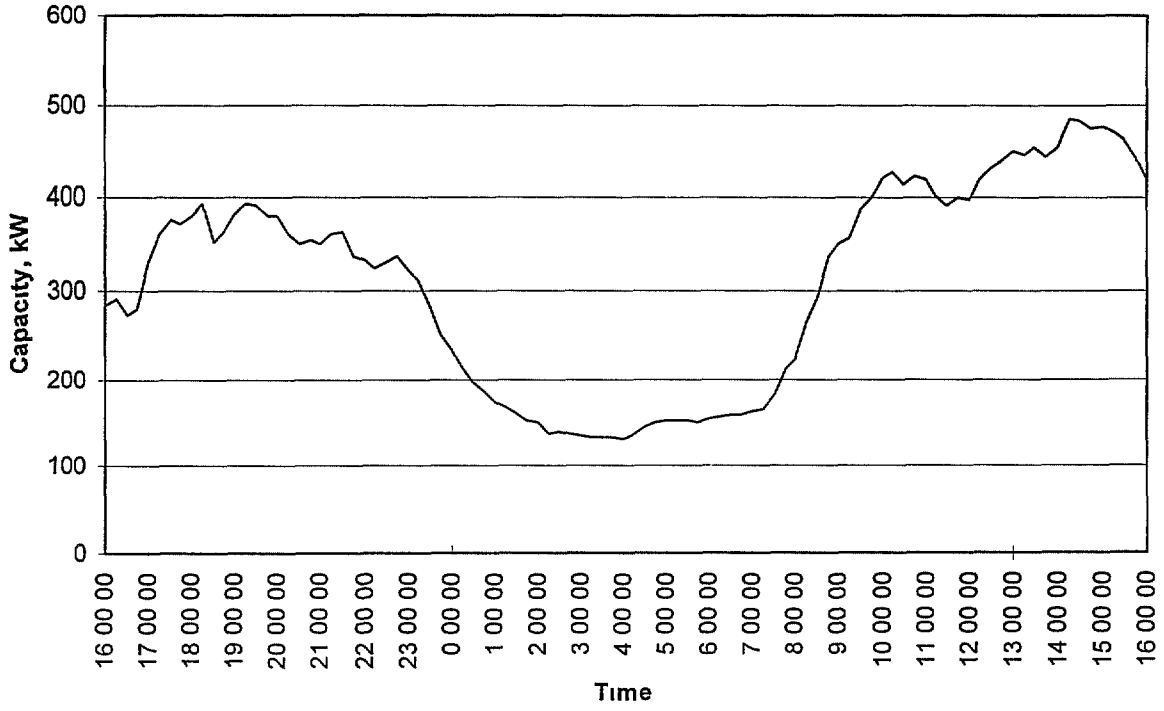


Fig IV-3 Electric power consumption of the boiler house, July 10-11, 1998

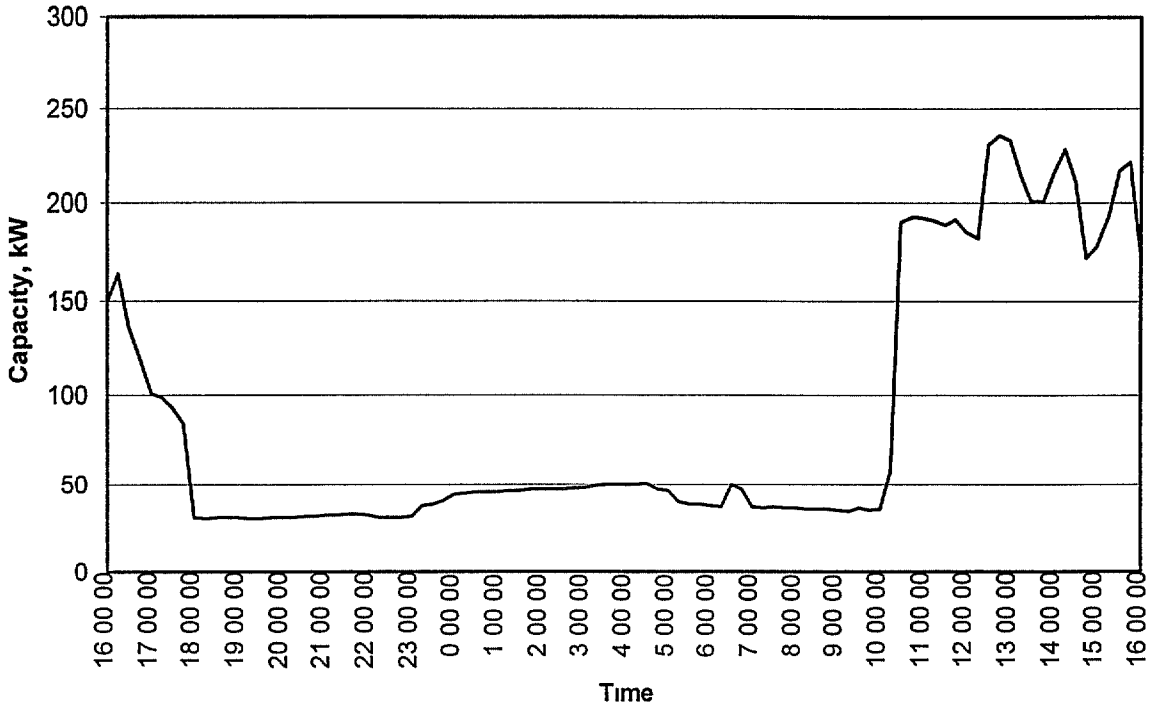


Fig IV-4 Electric power consumption of the lime shop, July 10-11, 1998

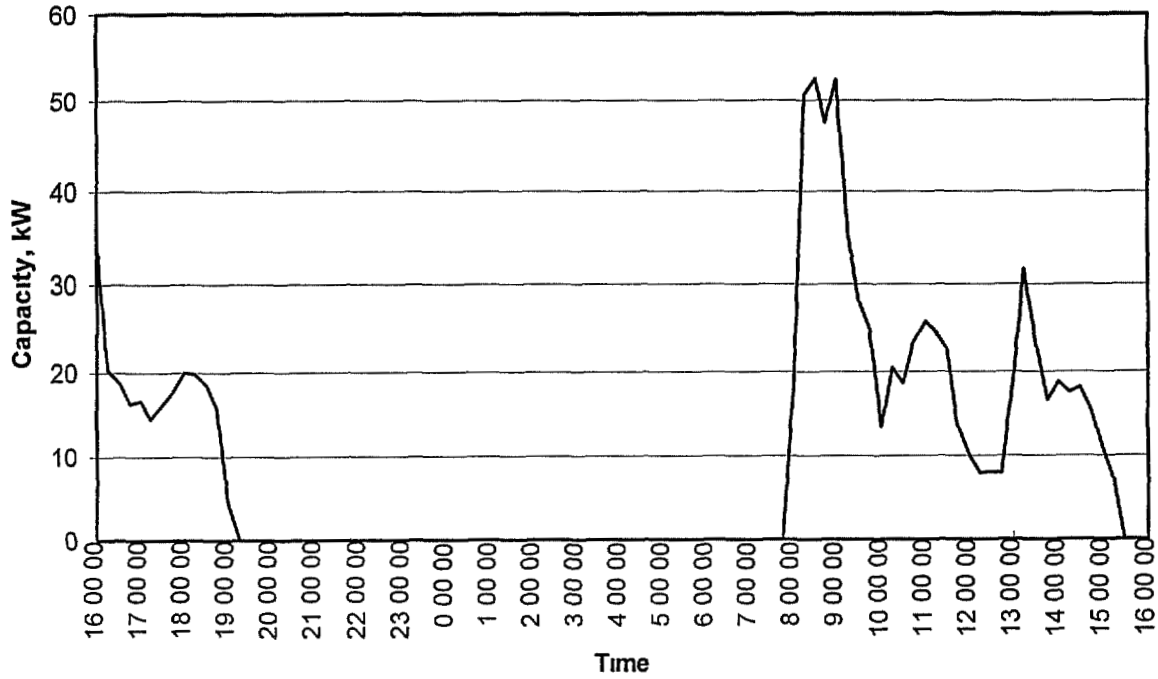


Fig IV-5 Electric power consumption of the silicate shop, July 10-11, 1998

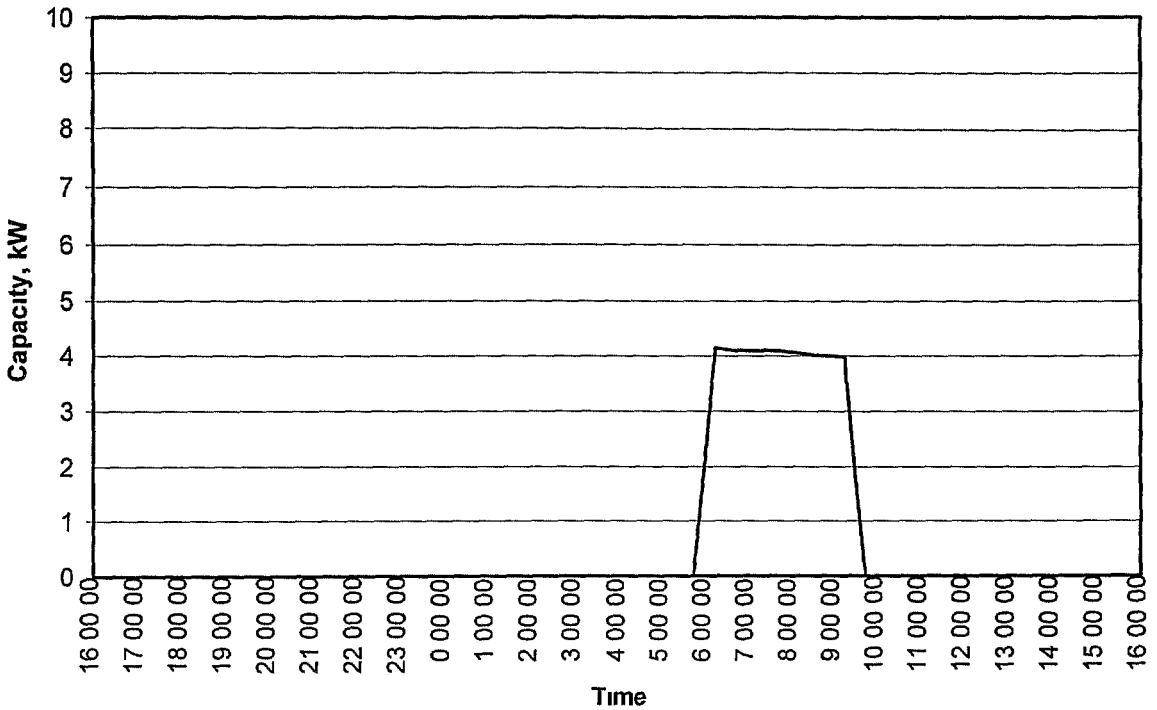
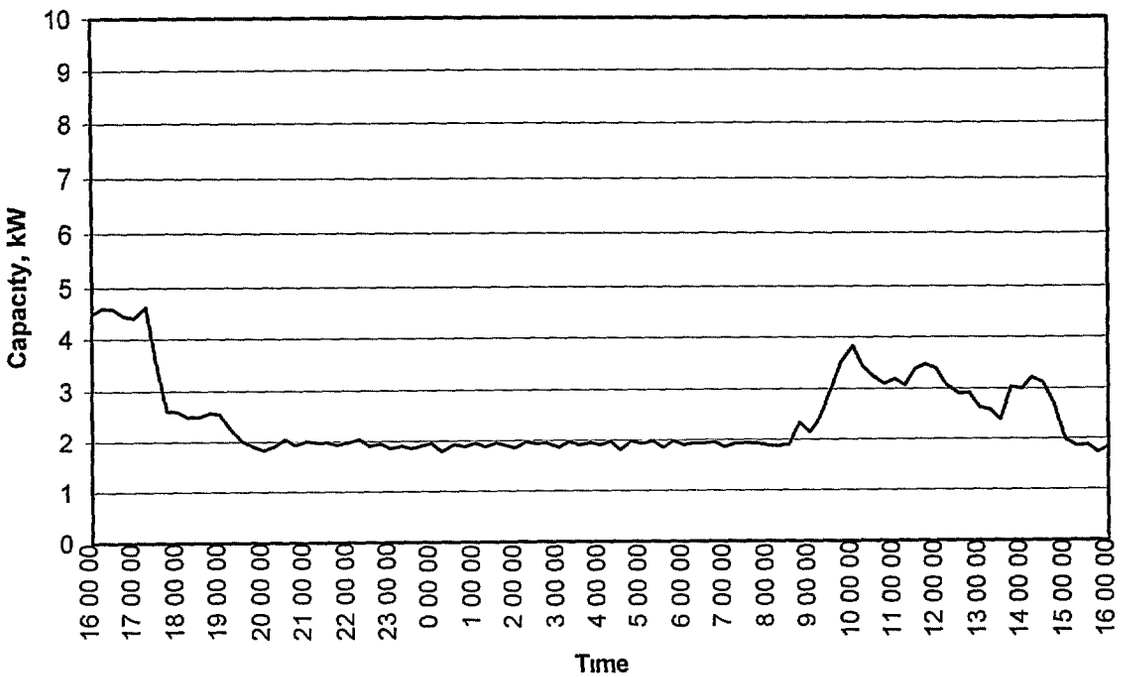


Fig IV-6 Electric power consumption of the administrative building, 10-11 July, 1998



APPENIDIX V HEAT LOSSES OF NON-INSULATED PIPELINES

№	Pipe location	Pipe length, m	Pipe diameter, m	Surface temperature, °C	Heat losses, kW
Boiler house					
1	steam pipeline	8	0 159	170	13
2	steam pipeline	22	0 300	170	60 5
3	feed pipeline	120	0 114	100	54
Pipeline to the silicate shop					
1	--	130	0 114	170	182
TOTAL					**309 5**

APPENDIX VI TESTS OF BOILER №8

Parameter	Unit	Test No	
		1	2
Test date		11 07 98	
Test time	hour min	16-50	
Steam output acc to the meter	t/hour		
Steam pressure	kgf/cm2	7 0	
Vacuum in the boiler	mm water		
Effluent gases after the boiler			
Temperature	°C	220	
Oxygen, O2	%	17 3	
CO2	%	3 2	
Excessive air	%	480	
NOx	ppm	22	
CO	ppm	790	
Losses with unburned CO	%	1 4	
Boiler Efficiency acc to the meter	%	52	
Feedwater			
Temperature before the economizer	°C	55	
Temperature after the economizer	°C	76	
Effluent gases after the economizer			
Temperature	C	125	
Oxygen, O2	%	18 4	
CO2	%	2 2	
Excessive air	%	735	
Heat losses with effluent gases	%	35	
NOx	ppm	16	
CO	ppm	590	
Losses with unburned CO	%	1 5	
Heat losses to ambient environment	%	8	
Boiler Efficiency acc to the meter	%	59	
Design Boiler Efficiency	%	55 5	