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ENERGY AUDIT

PERM LIME-SAND PANELS PLANT

Perm Oblast

RUSSIA

Prepared for

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1 EXECUTIVE SUMMARY

In March-May of 1998 OAO *Perm lime-sand panels plant*, Perm City underwent an energy audit within the framework of a project "Pilot project of introduction of power saving technologies" under USAID Program The study was performed by Russian experts in close contact with the facility personnel All the calculations and conclusions were done on the basis of an instrument survey of the facility power system, as well as of the data provided by the chief power engineering department

The purpose of the audit was to evaluate possible savings of energy resources and to apply the resulting conclusions and recommendations as the basis for further development of a structural approach to power savings at the enterprise

Hereinafter are the results of the audit

- The primary way of energy saving lies in the reduction of gas fuel and, consequently, of steam consumption The payment for natural gas comprises 15% in the production cost of commercial product and 50% of payments for natural resources (refer to Figure 1 1)
- The plant suffers from the lack of proper accounting and analysis of energy resource consumption by separated facilities This is a necessary condition for power saving The reliability of performance of gas and steam flow meters should be checked
- Cellular concrete products are the highest demand compared with other goods produced by the plant The cellular concrete shop is has been operated for 30 years It has become worn out and obsolete and currently is being re-equipped
- The plant has a large production area and the length of the steam and compressed air pipelines results in considerable power losses In the winter, due to the irregular operation, the condensate lines periodically freeze and the compressed air lines must be kept pressurized regardless of whether air is consumed It seems reasonable to move the steam and compressed air sources closer to their consumers In the course of the re-equipment of the cellular concrete shop, a mini-boiler house will be installed at the autoclave area with capacity of 7 t/h of steam It will result in the reduction of specific fuel and electric power consumption for steam production and reduction of heat losses The application of a higher steam pressure in the course of the autoclave concrete curing will improve the concrete strength properties and reduce the autoclave loading and reduce the specific steam consumption per unit of commercial product The switching of smaller consumers of compressed air to portable compressors at the location of air consumption will result in the reduction of compressed air losses and lower electric power consumption by the compressor station
- The primary way for steam savings at the enterprise is the utilization of the steam currently discharged during the autoclaves unloading It should be used in heat exchange for water heating for the hot water supply system Currently it is heated in the water boiler house The environmental impact of this process is also of great importance as the steam discharged to the atmosphere is contaminated with oils and paraffin While being utilized in the heat exchange the steam will undergo complete condensation, with the resulting condensate sent to the sewage system
- The boiler house of the plant produces saturated wet steam and due to the long length of the steam lines, the consumers receive steam with high condensate content Due to the high contamination, this condensate is only low amount of used in the boiler house The installation of separators will allow reduction in the steam humidity and will return clean condensate to the boiler house

- An air dryer is necessary to enhance the compressor station performance Also, state-of-the-art ball valves and clamps installation will reduce leaks (the price is $8 and $0 23 per one piece, respectively)
- The installation of an automatic electric power metering system will make it possible to introduce night rate for electric power and also for payments of the nominal capacity during the hours of maximum load in accordance with the actual obtained values It will reduce the nominal capacity by 10% Rescheduling of the performance of the mills in the cellular concrete shop, with their stoppage during the morning hours of maximum load, will reduce the nominal capacity by 400 kW
- An electric drive system audit revealed that in many cases, as with fans and conveyors in particular, the motors of increased capacity are used This results in motor inefficiency In the course of maintenance and repair, it is recommended that the motors be replaced with those of a lower capacity

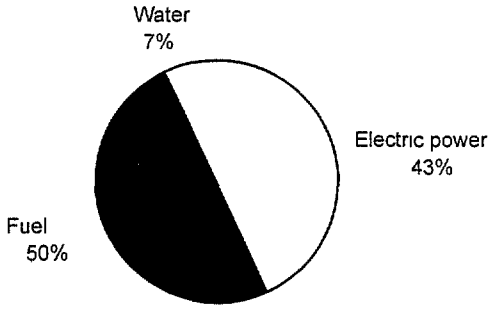


Figure 1 1 Breakdown of payments for energy resources

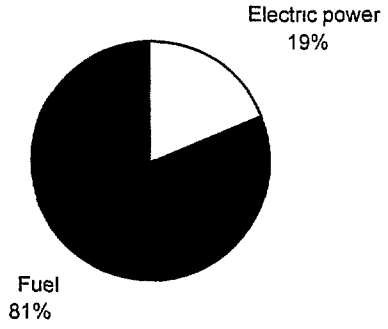


Figure 1 2 Breakdown of energy resources consumption (tons of standard fuel)

Below there is a list of the recommended power saving projects (refer to Table 1)

Table 1
Recommended power saving projects

No	Project	Unit	Saving		Project cost	Payback time
				Thou Rbl		
	No-cost projects					
1	Load optimization of steam-cure units at high-density concrete production	Gcal	5600	225	-	-
2	Optimization of the mills operation schedule at cellular concrete shop purposed to reduce nominal capacity for hours of maximum load	KW	400	332	-	-
3	Optimization of the operation of pit lime furnaces	Tons of standard fuel	73	18	-	-
	Low and medium cost projects					
4	Utilization of steam of unloaded autoclaves	GCal	7800	314	300	11 months
5	Condensate drum installation at facing tile shop	GCal water	450 1330	58	2	1 month
6	Disconnecting separate chambers while heating inactive filler	GCal	2074	83	8	1,5 month
7	Conversion of cellular concrete shop heating system from steam to water	GCal	883	35	70	2 years
	High cost projects					
8	Installation of separate low capacity compressors for small compressed air consumers	Thou kWh	1094	295	260	1 year
9	Introduction of automatic electric power metering system	Thou Rbl	-	200	500	2,5 years
10	Reduction of heat and electric power consumption	ton of standard fuel GCal	191 347	574	2000	3,5

The recommended projects will result in saving of heat energy of 17,154 GCal or about 2,745 tons of standard fuel, that is 264 tons of standard fuel for gas and 1094 MWh of electric power The enterprise will decrease payments due to the reduction of nominal capacity at the hours of maximum load and introduction of night rates by 532 thou Rbl, and will reduce treated water losses by 1330 m^3 The total fuel saving will comprise 3009 tons of standard fuel or 2663 thou m^3 with consequent reduction of carbon dioxide discharge by 107 thou m^3 In cash saving, expenditures and mean payback time will be 2,134 thou Rbl , 3,140 thou Rbl and 1 5 year, respectively

2 INTRODUCTION

The purpose of the energy audit of AO Perm lime-sand panels plant was to accumulate and analyse the data and information on the plant and its power consumers with the subsequent application of this information to recommend an efficient program of energy saving In the course of the audit retrospective data on power consumption, gas and other energy resources consumption and respective expenditures were obtained

State-of-the-art instruments were used during the audit including electric power analyzers, gas analyzers, ultrasonic flow meters, electronic thermometers and other devices

3 PLANT DESCRIPTION

The open joint stock company *Perm lime-sand panels plant* was constructed in 1956 and the lime-sand concrete has been produced since 1966 The plant includes the following subdivisions lime burning shop, facing tile shop, cellular concrete shop, high-density concrete shop, steam and water heating boilers and, a compressor station The mix and annual production quantities of the main commercial products are shown in Table 3 1

Table 3 1
Commercial products mix and quantities in 1997

No	Month	Cellular concrete, m^3	High-density concrete, m^3	Facing tile, m^2	Lime, t
1	January	2,533	1,482	2,416	2,052
2	February	3,210	1,478	3,215	–
3	March	3,701	1,422	2,636	2,210
4	April	4,086	1 253	1,946	–
5	May	2,248	788	1,894	2,220
6	June	4,426	1 741	2,322	684
7	July	6,322	1,377	3,126	1,911
8	August	7,844	1,805	1,546	2,029
9	September	6,308	264	3,143	1,345
10	October	6,751	940	2,942	1,429
11	November	4,083	642	2,544	1,661
12	December	4,798	533	2,218	826
13	Year	56,310	13 755	29,948	16,367

The plant is supplied with the following utilities natural gas, electric power and water Medium pressure natural gas (6 atm) is used for lime burning in pit furnaces and during heat production in a boiler Commercial gas consumption is controlled separately for the boilers and for the lime shop A gas distribution unit has one flow meter DSS-712 for the steam boiler, two flow meters DSS-712 for the water heating boiler, one flow meter DSS-711 for the lime plant and two flow meters DSS-711 for the gas distribution station The entire plant gas consumption is controlled with the help of KSD1-002/DM-3583 flow meters In 1997 the plant consumed gas and fuel oil (backup) in the amount equivalent to 22,695 t and 747 t of conventional fuel, respectively

Electric power is supplied to the plant by three feeders 35 kV each two feeders from the Akulovskaya substation to GPP PZSP and one feeder from the Proletarskaya substation to GPP Kaskad From GPP, the power at 6 kV is supplied to 13 plant transformer substations, their specifications are shown in Table 3 2

Table 3 2
Transformer substations specifications

No	Substation	Voltage, max/min, kV	Transformer type	Number of transformers	Notes
1	GPP Kaskad	35/6	TDNS-10000	2	
2	GPP PZSP	35/6	TM-4000	1	
3	TP-1	6/0 4	TM-1000	3	1 stand-by
4	TP-2	6/0 4	TM-180	3	1 stand-by
5	TP-3	6/0 4	TMZ-400	1	
6	TP-4	6/0 4	TM-400	1	
7	TP-5	6/0 4	TM-180	1	
8	TP-6	6/0 4	TM-400	1	
9	TP-7	6/0 4	TM-320	1	
10	TP-8	6/0 4	TM-400	1	
11	TP-11	6/0 4	TMZ-1000	1	
12	TP-12	6/0 4	TMZ-630	2	1 stand-by
13	TP-13	6/0 4	TMZ-630	1	
14	TP-14	6/0 4	TMZ-1000	1	
15	TP-15	6/0 4	TMZ-1000	2	1 stand-by
16	TP-19	6/0 4	TM-400	2	1 stand-by
17	TP-10	6/0 4	TM-400	2	

The operating voltage of the power equipment is 380 V Three compressors of the air compressor station use 6 kV The principal electric power supply scheme of the plant is shown on Figure 3 1

The electric power consumption is measured by three active power electric meters installed at the service entrances In 1997, 16,842 MWh were consumed For the settlements with the sub-consumers, 27 electric meters are installed at GPP (15 meters of active power and 12 meters of reactive power) Meters installed at 20 transformers 6/0 4 kV measure the plant consumption of electric power

The plant utilizes pipeline and artesian water for both process and utility needs, and in the cooling systems of the compressors In 1997, the plant consumed 179 thousand m^3 of pipeline and 166 m^3 of artesian water

Process steam is generated at a steam boiler house with 6 boilers three DKVR 6 5/13 and three DKVR 10/13 boilers Hot water for the plant and settlement heating and for the hot water supply system is produced at the water heating boiler house with 4 boilers two kV-GM-130 and two reconstructed DEV-10-14GM boilers

Compressed air is produced by the compressor station equipped with three 2VM-10-63/9 compressors of 63 m^3/hour capacity and two compressors of 20 m^3/hour capacity Compressed air is used for cement unloading from rail cars and its pneumatic transportation from the silos to the consumption drums It is also used for pneumatic transportation of ground lime to the process, as well as for the pneumatic control of equipment at different areas, and other auxiliary needs

The priority processes of the plant are the cellular concrete production (Shop No 1), the high-density concrete production (Shop No 7), the facing tile shop and the lime shop

3 1 Cellular concrete shop

The cellular concrete production process includes the following stages grinding of lump lime and wet grinding of sand in ball mills Ground lime and sand are sent by the pneumatic expander tube pumps to the concrete mixer where the components are mixed with gasifier (aluminum powder) The resulting mix is poured into a form where it gets bloated and settles, providing the initial wet strength Two main types of cellular concrete products are produced panels and non-reinforced blocks At the block production, the bloated concrete mix at the stage of a proper wet strength is cut into blocks of needed dimensions The concrete gets its brand strength in the course of steam curing in an autoclave

where the blocks are heated with steam at 8 atm pressure and 178°C Autoclaving takes 16 hours The resulting condensate is contaminated with oils and paraffin from the formwork lubrication and cannot be returned to the boilers The condensate is mainly discharged to the sewer system and is partly used in the process of concrete mix preparation Under the process conditions the steam from curing should be sent to the newly loaded autoclave However, as the production capacity is not used completely and production is random the steam at 4 atm is used for heating water in a 20 m^3 tank by bubbling At a pressure below 4 atm, the steam is discharged to the atmosphere, as the water head does not permit purging Hot water is used for heating of a greenhouse and some of the plant facilities

Structures for reinforcing the cellular concrete are produced with steel bars at the reinforcement area of the shop with the help of multi-spot and single-spot welding machines

The shop design output is 91 8 thou m^3, current shop output is 61 2% of capacity In accordance to production process plant norms, the energy resources consumption are the following 430 MCal of steam, 130 m^3 of compressed air, 0 6 m^3 of water and 24 kWh of electric power per 1 m^3 of concrete

The main process equipment specification is shown in Table 3 3

Table 3 3
Specification of main process equipment for compact concrete

No	Equipment	Type	Number	Dimensions, m	Output capacity	Year of commissioning
1	Autoclave, m^3	AT-3 6-21 AT-3 6-27	6 2	3 6 × 21 3 6 × 27	66,6 88,8	1967-1969 1989-1990
2	Lime mill t/h	SM-1456 AUZ	3	—	8	1996
3	Sand mill, t/h	SM-1456 AUZ	3	—	8	1996
4	Expander tube pump, m^3/min	TA-23B	2	—	14,4-19	1992
3	Sand mill, t/h	SM-1456 AUZ	3	—	8	1996

The shop operation regime depends on the demand of commercial products normally one shift, 5 working days a week in winter and two shifts every day at other seasons

3 2 High-density concrete shop

The high-density concrete shop consists of 5 process trains differing by the type of steam curing units Train 1 uses slotted steam chambers for products processing, Train 2 uses cassette units for this purpose, Train 5 uses pit chambers, Train 3 uses pit chambers and special formwork, Train 4 uses cassette units and special formwork

The high-density concrete production process includes the following stages Cement supplied to the plant in cement trucks and rail cars is unloaded with the help of compressed air by expander tube pumps (TA-15, capacity 12 m^3/min) to silos, wherefrom it is sent by pneumatic screw pumps to process drums A NPV-63 pneumatic screw pump of 22 m^3/min capacity supplies cement to a mixer Neutral fillers, sand and gravel are delivered to the plant by railway and unloaded to the open storage area by a system of conveyers, wherefrom the other conveyer system sends it to the concrete mixer Nonreactive fillers and cement are mixed in a concrete mixer with addition of an appropriate amount of water Concrete mix is unloaded to a concrete placing machine From the placing machine, concrete is unloaded to a vibrator table with a preliminary laid reinforcement At vibrator table concrete achieves high density Brand strength is obtained by the concrete in the course of steam curing both by *sharp* and *dead* steam at 80°C during 10 hours Fabricated products are stripped of the forms and transported to the storage area by a traveling crane Steam from the boiler house is at 5 atm

and downstream of a relief valve 1 1 atm and 112°C The process trains specification is shown in Table 3 4

Table 3 4
Process norms of energy resources consumption

Train No	Unit	Output capacity, m^3/d	Steam consumption, t/h	Year of commissioning
1	Slot chamber No 1 Slot chamber No 3	50 50	3,900 150	1987
2	Cassette No 1 Cassette No 2 Cassette No 3 Cassette No 4	20 19 19 19	8,625	1987 1987 1983 1983
3	Pit chambers No 1-10		1,226 7 1,083	1988
4	Special formworks ShL-1, 2 SK-1-6 Ventilation unit Straightway unit LM-1, 2 KKS-1 4	 1 83 2 13 1 6 — 0 68 0 95	1,893 1 414	 1987 1993-1995 1987 1995 1988 1993
5	Pit chambers No 1, 4, 7, 10	—	925	1993

3 3 Facing tile shop

The shop design output is 350 m^2 of tile per day that is equivalent to 10 m^3 of concrete Currently the shop output is 24% of 1997 Norms of energy resources consumption are the following 15 MCal of steam, 5 m^3 of compressed air, 0 16 m^3 of water and 7 kWh of electric power per 1 m^2 of tile

The shop was commissioned in 1990 and the operation regime is one shift a day, 5 working days week

3 4 Lime shop

Two pit furnaces for lime burning (7 8 × 16 m) 120 t/d of output capacity are installed in the lime shop Currently, due to low lime demand only one furnace is performing from time to time that provides usage of only ---% of the shop capacity

The stock for the lime production is graded limestone, with grades of 40 mm to 70 mm in size It is supplied in rail cars and is unloaded to an open storage area by a system of conveyers, the other system of conveyers delivers it to furnaces Lime is burned by the counterflow method limestone moves downwards, hot stack gas produced by burning of natural gas provides 1,000°C in the burning zone and moving upstream heats the limestone Burnt lump second rate lime with activity of 80% is used in cellular concrete production, as well as a commercial product Gas is burned in 16 periphery diffusion tuyeres of VNIIstrom design Aerodynamic regime of work of the furnace is provided with DN-12 5 smoke extractor with electric drive of 75 kW The cleaning of stack gas from dust is performed in combined cyclones of NIIGAZ design (∅ 600 mm, 4 pieces)

Energy resources consumption norms per production of 1 t of lime are the following fuel equivalent to 159 kg of conventional fuel, electric power — 15 kWh

4 ANALYSIS OF ENERGY CONSUMPTION AND EQUIPMENT PERFORMANCE SPECIFICATION

4 1 Energy consumption breakdown

Energy consumption breakdown both in natural and cash is shown on Figure 4 1 The main energy resource for the plant is natural gas its share is 81% and 50% in consumption and payments, respectively

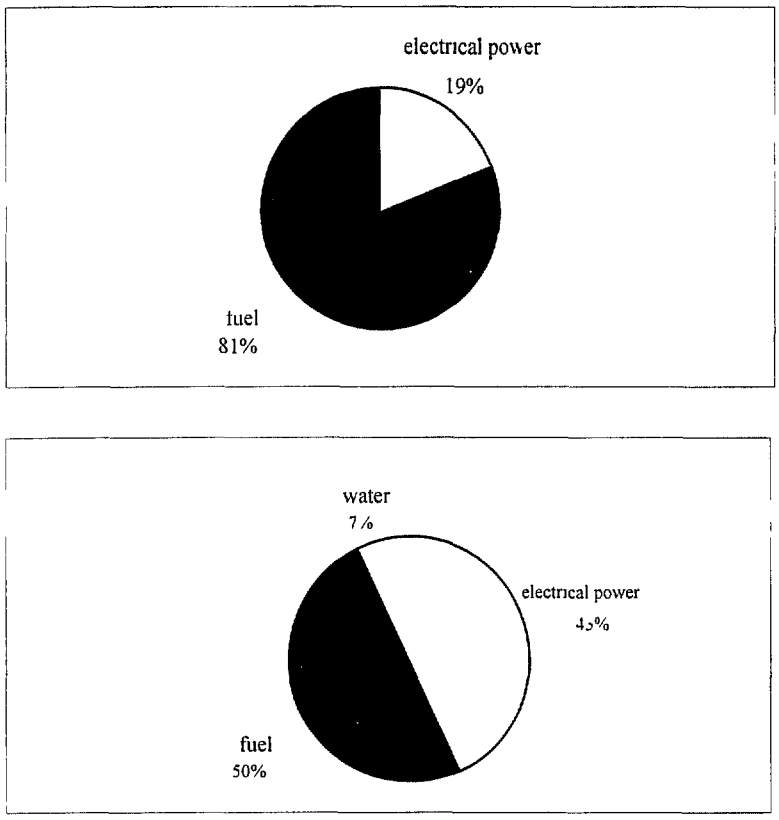


Figure 4 1 Energy consumption layout both in natural form and cash

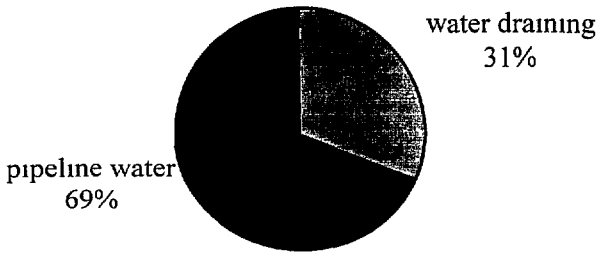


Figure 4 2 Payments for water consumption and water draining

Energy resources rate changes in 1997 and rates affective as of 01 03 98 are shown in Table 4 1

Table 4 1
Energy resources rates in 1997

No	Energy resource	Months			
		Jan 1997	Feb 1997	Jan 1998	March 1998
1	Fuel for boilers and furnaces	289,177	284 100	284 1	284 1
2	Electric power				
2 1	For consumed electric power, Rbl/kWh	192	192	0 19	0 27
2 2	For consumed power, Rbl/kW	66,000	66,000	66	69 1
2 3	For consumed reactive electric power Rbl/kVARh	17 04	17 04	0 17	0 17
2 4	For consumed reactive power Rbl/kVAR	5,280	5 280	5 28	5 28
3	Water				
3 1	Pipeline water consumption, Rbl/m^3	3,960	3 960	3 96	3 96
3 2	Artesian water consumption, Rbl/m^3	12	12	0 012	0 012
3 3	Water draining Rbl/m^3	2 324	2 324	2 32	2 32

As of November 17, 1997 a new system of calculation was offered to industrial consumers with differentiation of rates with regard of the time of the day The system provides for installation of an automatic recording of consumed capacity and electric power Payment will comprise 125% and 75% of electric power rate during periods of maximum load and at nighttime, respectively, while in between this period it will comprise 100% The electric power consumed during hours of maximum load shall be paid with regard to actual value Payment components for electric power are shown on Figure 4 3

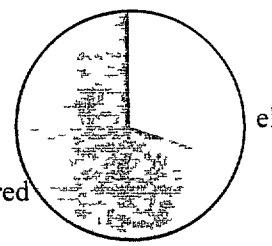


Figure 4 3 Payment structure for electric power in 1997

The cost breakdown is shown in Table 4 2, payments for energy resources, including water, is 24% (including 15 9% for natural gas)

Table 4 2
Cost breakdown in 1997

No	Costs	Share of costs, %
1	Material costs including	57 7
1 1	Materials	33 7
1 2	Electric power	7 0
1 3	Fuel	15 9
1 4	Water	1 1
2	Wages	17 2
3	Deductions from wages fund	6 6
4	Capital assets wear	9 7
5	Miscellaneous	8 8

The share of payments for energy resources in the cost structure for the plant is 24% including payments for natural gas comprising 15 9% Thus, the main way to save energy is through the program of saving of fuel and steam

4 2 Gas fuel consumption

Natural gas is used at the plant as boiler and furnace fuel, fuel oil is used as backup fuel The fuel oil storage has capacity of 1500 t and the current reserve stock is 500 t The seasonal gas consumption by different consumers is shown in Table 4 3

Table 4 3
Season gas consumption

Month	Furnaces		Steam boiler house		Water boiler house	
	Lime output, t	Gas consumption, equivalent tons	Steam production, GCal	Fuel consumption, equivalent tons	Heat production, GCal	Fuel consumption, equivalent tons
January	2,052	250	3,340	3,220	14,990	2,120
February	—	—	3,030	2,317	11,390	1,610
March	2,210	250	2 810	2 317	9,870	1,395
April	—	—	2,975	1,752	7,910	1,125
May	2,220	300	2,040	1,186	3,230	460
June	684	140	2,220	700	1,150	160
July	1,911	200	3,620	960	980	135
August	2,029	290	3,980	1,169	1,280	180
September	1,345	200	3,820	1,164	2,050	290
October	1,429	210	4,300	1,895	5,930	835
November	1,661	240	3,790	2,738	11,600	1,640
December	826	190	4,640	3,277	14,380	2,035
Year	16,367	2,270	40,565	5,537	84,760	11,985

The structure of fuel consumption by different consumers versus output of 1997 is shown on Figure 4 4

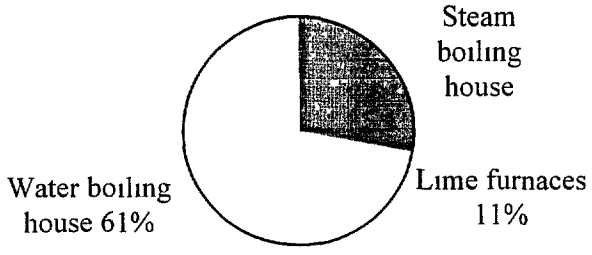


Figure 4 4 Structure of gas consumption by different consumers in 1997

The above data reveal that the main gas consumer at the plant is a water-boiler house 61% of the total consumption The generated heat energy is used for the heating of plant facilities and of a settlement About 10% of the heat energy is consumed for plant heating and comprises about 6% of the total gas consumption Thus, the steam boiler house and the lime furnaces are the main plant gas consumers The steam boiler house producing steam for the production process consumes 28%, and the lime shop consumes 11% of the total gas consumption

For the evaluation of gas consumption, the most indicative value is specific consumption of energy resource per unit of commercial product The actual specific gas consumption in the lime production with regard to its output varies from 100 to 200 kg of conventional fuel per 1 t of lime (refer to Figure 4 5) An increase of specific fuel consumption with the reduction of lime production results from the irregular supply of limestone which causes insufficient loading of the pit furnaces This also results in an increase of the temperature of stack gas The fuel consumption norms for lime burning in pit furnaces is 120 kg of conventional fuel per 1 t of lime

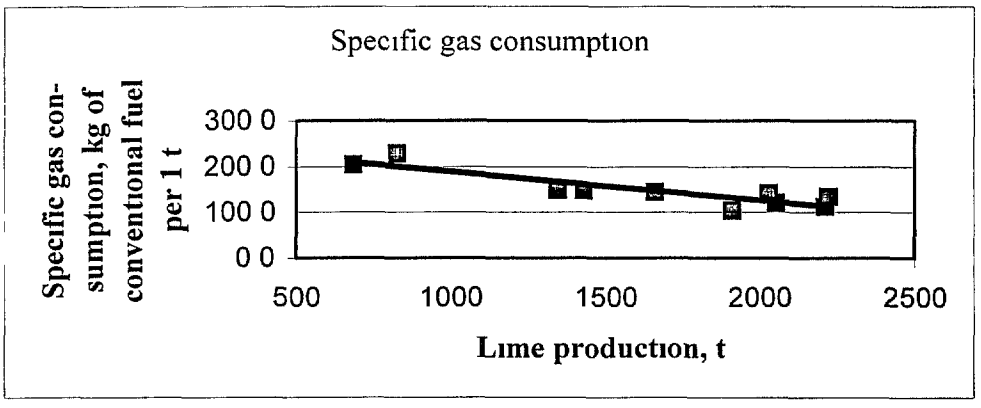


Figure 4 5 Specific fuel consumption at lime burning in 1997

The water-heating boiler house produces heat energy for heating of the plant facilities and the settlement The efficiency of its use by the main consumer, that is the settlement, is not included in the tasks of the current project The evaluation of efficiency of fuel at the steam and water-heating boiler houses is described in Section 5

4 3 Heat energy consumption

The primary way of fuel saving is the saving of steam for production purposes The main steam consumers at the plant are as follows production of cellular and high-density concrete, and facing

tile, heating of fuel oil in a fuel storage, and the heating of nonreactive fillers and heating of a part of facilities for the cellular concrete production in winter At the cellular concrete and high-density concrete shop, the heat energy consumption is under control The steam consumption structure is shown on Figure 4 6

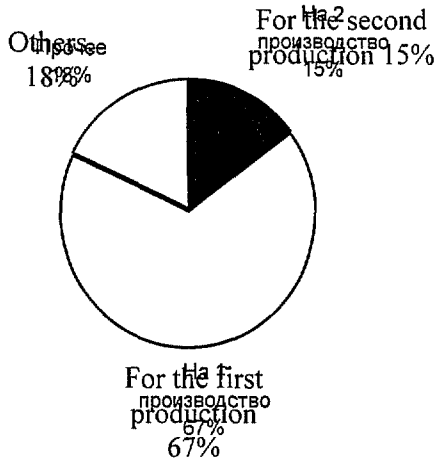


Figure 4 6 Steam consumption structure

Specific steam consumption for the production of cellular concrete ranges from 450 to 500 MCal/m^3 with regard to output volume (refer to Figure 4 7)

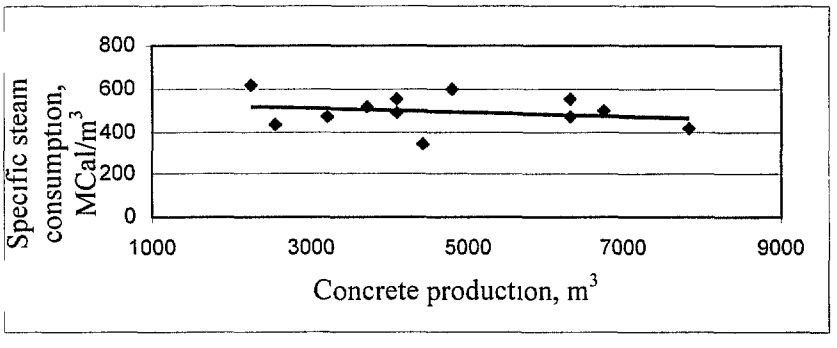


Figure 4 7 Specific consumption of heat energy for production of cellular concrete

The data reveal that the specific heat energy consumption only slightly depends on the production volume This supports the idea that the autoclaves, wherein steam curing of concrete is performed, are working at full capacity For the industry the mean values of specific steam consumption at cellular concrete production are 250-350 MCal/m^3 Excessive steam consumption results from the steam relief from the unloaded autoclaves to newly loaded ones due to unstable production While being discharged from the autoclave steam changes pressure from 8 to 3 atm and heats water in a tank for a greenhouse It should be noted that such steam utilization is of a seasonal character At a steam pressure below 3 atm, the water head in the tank does not permit bubbling and the steam is discharged to atmosphere Note that spent steam is contaminated with oils and paraffin used for formwork lubrication, so its discharge produces a certain environmental impact To eliminate the above discussed negative features, it is necessary to use the spent steam for water heating in pipe heat exchangers This is for a hot water supply system that is currently fed from water-boiler house On the other hand, the steam will be entirely condensed and discharged to a sewage system, i e any possible environmental impact will be eliminated The efficiency of the described program might be about 3000 GCal/year

The heating of facilities of cellular concrete shop is performed by steam Another saving may be achieved by using hot water instead of steam The heat energy consumption is calculated by the formula [1]

$$Q = q \times V \times (t_B - t_H) \times 24 \times To \times 10^6, \text{ GCal}$$

where
q is a specific heating value of 0,25 Kcal/m^3 h°C,
t_B — inner temperature with regard to heat radiation, 12°C
t_H — mean air temperature during heating period, –3,6°C
V — facility volume, 95,249 m^3
To — duration of heating period, 213 days

Estimated heat consumption is 2,350 GCal, heat losses in the system in the event of lack of condensate drums will achieve up to 50%, and at losses of about 30% the actual heat consumption will be about 3050 GCal The conversion from steam to water heating will provide 6% heat saving or 183 GCal, i e 31 tons of standard fuel

The values of actual specific heat energy consumption at production of high-density concrete excluding steam consumption for heating of nonreactive fillers vary from 200 to 800 MCal/m^3 (refer to Figure 4 8)

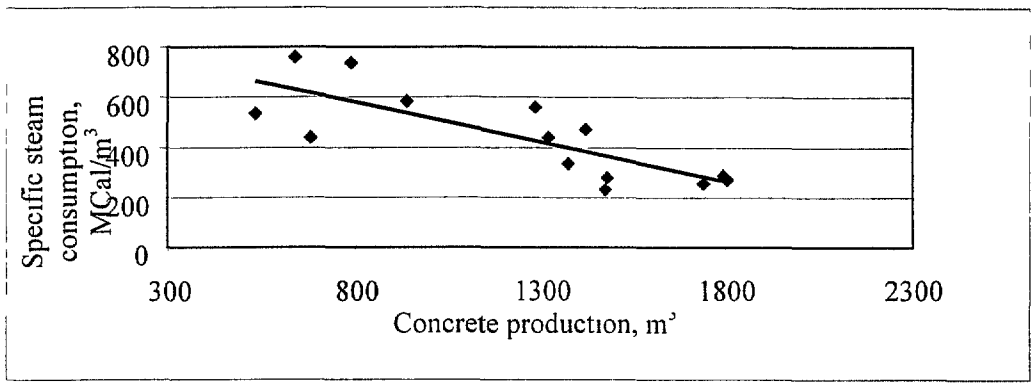


Figure 4 8 Specific steam consumption at high-density concrete production in 1997

The specific steam consumption at the high-density concrete production shows that in the case of output reduction energy consumption per unit of product considerably increases This results from the fact that with reduction of capacity the loading of the steam curing units reduces as well (it is a peculiar feature of pit steam curing chambers) and the steam efficiency is low Unstable performance and the high number of regimes of steam curing the factor of filling of a steam chamber may be very low At the normal loading of producing facilities, the specific steam consumption, excluding consumption on heating of fillers is 300 MCal/m^3 (refer to Figure 4 8) That complies with the norms for the industry The steam losses in 1997 (during September, October, November, December and May) by this reason at a mean specific steam consumption during these months of 600 MCal/m^3 may be approximately evaluated as follows

$$Q_1 = (788+264+940+642+533) \times (600 - 300) = 700 \text{ GCal}$$

The steam consumption is measured at the cellular and high-density concrete shop and steam production is calculated at a boiler house Note that steam measurement with steam flow meters does not provide the entire real situation This is supported with data of Appendix 1 To evaluate the steam consumption by other consumers and the steam losses, the steam balance is integrated in Table 4 4 for 1997

Table 4 4
Steam production and consumption in 1997

No	Steam production, GCal	Steam consumption by cellular concrete shop, GCal	Steam consumption by high-density concrete shop, GCal	Miscellaneous consumption
1	3,340	1,100	410	1,830
2	3,030	1,500	338	1,192
3	2,810	1,893	672	245
4	2,975	2,005	722	248
5	2 040	1,385	582	173
6	2,220	1,503	440	277
7	3,620	2,970	461	189
8	3,980	3,215	498	267
9	3,820	3,457	409	54
10	4,300	3,377	549	374
11	3,790	2,267	486	1,037
12	4,640	2,870	287	1,483
year	40,565	27,342	5 854	7,369

The steam consumption for production of cellular and high-density concrete, as well as for heating of Production No 1 is measured with steam flow meters Steam is used for other purposes as well (7369 GCal or 18% of total steam consumption) at the facing tile shop, for fuel oil heating in the storage, as well as for the heating of nonreactive fillers in winter This amount also includes the heat energy losses in the networks especially during wintertime and losses with condensate and the straightway steam Condensate actually never returns to the steam boilers in winter as the condensate lines get frozen The inspection of a steam supply system of the facing tile shop (April 1998) revealed that the condensate line had been cut and spent steam was discharged to atmosphere Note that the steam temperature drop between the inlet to the shop and a condensate line was 30°C Due to the lack of a condensate line no condensation occurs and, consequently, the hidden heat of steam generation is not used (r=510 Kcal/kg) but only the heat of steam cooling (about 30 Kcal/kg) If the obtained steam-condensate mix is sent back to a boiler house through the restored condensate line the actual heat losses with the straightway steam with regard to a necessity of its cooling to 80°C will comprise 400 Kcal/kg or 78% of steam being sent to the facing tile shop In accordance with the inner plant norms, the specific steam consumption is 15 MCal/m^2 For 1997, at the production output of 29948 m^2, the annual steam consumption should be the following

$$Q_2 = 29948 \times 0{,}015 = 449 \text{ GCal}$$

The actual steam consumption with regard to the calculation shown above may achieve Qa = 800 GCal

Note that the steam lines are rather long due to large production areas (refer to a Figure of Appendix 3) A boiler house generates wet steam at 10 atm (no steam heaters are available) The insulation of the surface steam lines is satisfactory Heat losses were calculated by the following formula [4]

$$QP = q \times L \times T \times 10^6, \text{ GCal/year}$$

Where
L is the pipeline length, m,
T is the yearly working hours, 8,760 h,
q is the specific heat loss, KCal/m h

The calculation of heat losses in steam lines is shown in Table 4 5

Table 4 5
Heat losses in steam lines

No	Shop of destination	Steam line lengths (L) m	Steam line diameter (D), mm	Specific heat losses, Kcal/mh	Heat losses, GCal/year
1	Cellular concrete	300	219	132	347
2	High-density concrete	300 40	159 200	93 110	244 39
3	Facing tile	300	57	58	152
4	Fillers storage	160	159	93	130
5	Fuel oil storage	66	100	76	44
6	TOTAL				956

The steam consumption for heating of nonreactive fillers from November till February can be approximately evaluated by the difference in seasonal steam consumption The mean monthly steam consumption for the facing tile production and the fuel oil heating may be assumed as relatively constant and can be evaluated by consumption from March till October 1997 (refer to Table 4 4) as 228 GCal The seam consumption for heating of nonreactive fillers (during 4 above months) is

$$Q_2 = [(1{,}037 + 1{,}483 + 1{,}830 + 1{,}192) - 4 \times 228] = 2{,}983 \text{ GCal/year}$$

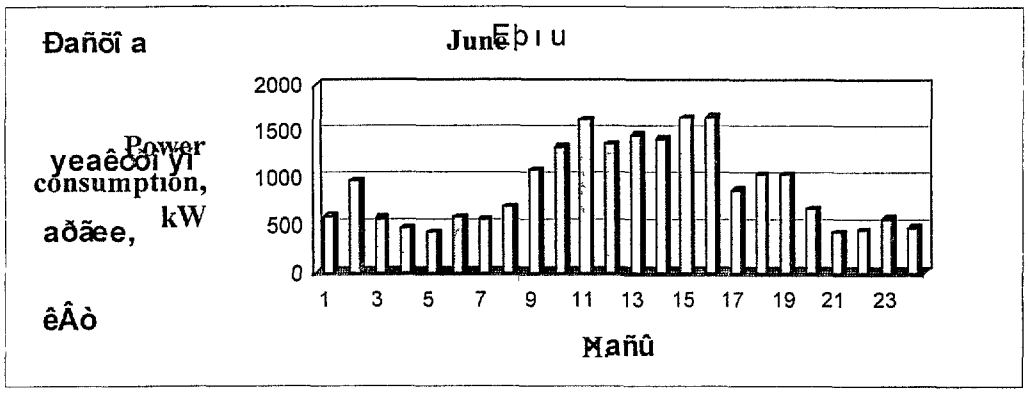
The normative specific steam consumption per 1 t of nonreactive fillers q_H = 30 MCal/t [2], yearly consumption norm is 300 GCal, i e the losses may be assumed as 2,683 GCal

The large steam losses while heating the nonreactive fillers, results from the fact that the heaters are in critically bad conditions Their repair is rather complicated as the steam feed is sequential and there is no possibility to shut the separate chambers Besides, the chamber is heated irrespective of the fact if it is full or empty To reduce the steam consumption at this section, it is necessary to install steam valves for shutting the separate chambers (14 valves) The heat energy saving resulting from compliance with steam consumption norms for the nonreactive fillers heating with regard to the estimated losses of 609 GCal at the steam lines (refer to Table 4 5) will comprise 2,074 GCal

After the fillers heating the condensate is returned to the boiler house in low amounts as it is contaminated To return clean condensate and to send dry steam to the shop installation of the separators is recommended at the inlets to the shop

4 4 Electric power consumption

The daily charts of electric power consumption makes it possible to analyze the level of the consumed capacity during hours of maximum load as well as the schedule of the basic energy consuming equipment at different seasons Figure 4 4 shows charts of daily active power load in winter (December) and in summer (June)



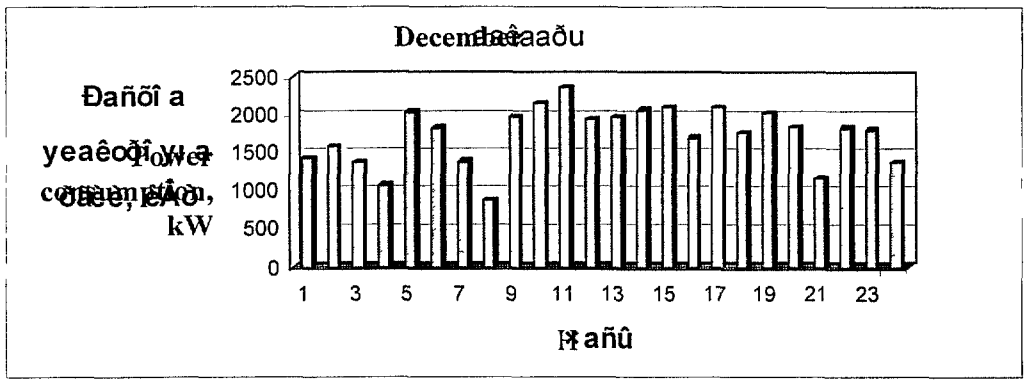


Figure 4 9 Daily active power load in winter and in summer

The power supplier has offered the plant to introduce time-of-the-day differentiated rates which are 125%, 75% and 100% of effective rate for hours of maximum load night hours and intermediate periods, respectively The offered payment system supposes installation of an automatic system of power consumption recording The power consumed is paid for in accordance with the recorded values To evaluate the reasonability of the introduction of the offered rate, the daily structure of power consumption has been studied for winter and summer periods (refer to Figure 4 10) In summer power consumption during peak and night hours is similar (20% and 21%), i e during this period a new rate gives no saving In winter power consumption during night hours exceeds that of the hours of maximum load (22% and 30%) on the average by 4% per month

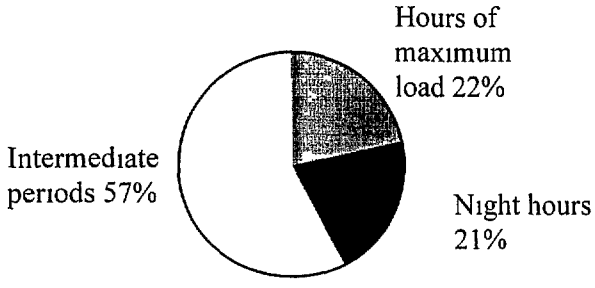


Figure 4 10 Daily structure of power consumption in summer

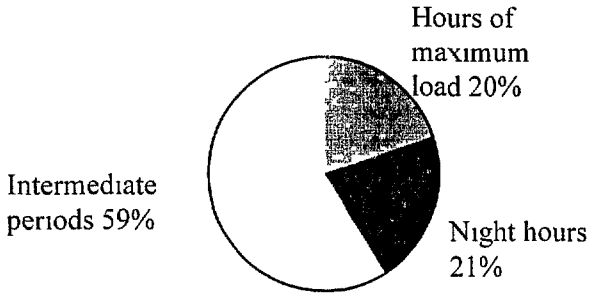


Figure 4 11 Daily structure of power consumption in winter

The total saving resulting from introduction of the offered rate for the power consumed in October-March of 1997 (at rate 0 27 Rbl/kWh) will comprise

$$Et = (1,780 + 1,786 + 1,541 + 1,394 + 1,722 + 1,927) \times 10^3 \times 0,27 \times 0,04 = 110 \text{ thousand rubles}$$

5 ENERGY RESOURCE SAVINGS

5 1 *Boiler house*

The efficiency of fuel utilization in the steam and water boiler houses is evaluated through boilers' efficiency The boilers latest maintenance took place in 1997 On April 10 an instrument inspection of the boilers, with the help of Bacharach gas analyzer was performed with the purpose of evaluation of boilers' efficiency and in accordance with maintenance schedule At this time, only one kVGM-30-150 boiler of nominal heat capacity of 30 GCal/h and water temperature 150°C was operating At the moment of inspection, the water temperature in the feed line was 84°C and in the return line 54°C The gas and air pressures upstream of the burners comply with the second regime of the process sheet

In the steam boiler house, two DKVR 10 13 boilers (No 5 and 6) were operated

The layouts of the steam and water boiler houses are shown on Figure 5 1 and 5 2

The actual values of boilers' parameters as well as values according to a process sheet are shown in Table 5 1

Table 5 1
Values of parameters of steam and water boiler houses

No	Boiler	Heat generation, GCal/h	Outlet gas composition				
			O_2, %	CO, ppm	α	T, °C	η, %
1	KVGM-30-150	14 82					
	Inspection		8 0	1	1 54	124	94 7
	By process sheet		3 9	—	1 18	140	91 7
2	DKVR 10/13 No 6	8 2					
	Downstream of boiler Downstream of economizer		3 9 6 7	195 250	1 23 1 44	300 258	89 5
	By process sheet						
	Downstream of boiler Downstream of economizer		3 8 6 8	— —	1 23 1 43	290 145	90 9
3	DKVR 10/13 No 5	7 5					
	Downstream of boiler Downstream of economizer		5 6 7 8	9 12	1 33 1 54	300 250	88 9
	By process sheet						
	Downstream of boiler Downstream of economizer		5 2 6 8	— —	1 3 1 46	245 145	90 9
4	DKVR 10/13 No 4	7 5					
	Downstream of boiler Downstream of economizer		6 4 10 1	24 5	1 4 1 85	361 170	82 2
	By process sheet						
	Downstream of boiler Downstream of economizer		5 2 6 8	— —	1 3 1 46	245 145	90 9

The surface temperature of boiler's insulation is 25-40°C The losses to the environment are within the norms The suction in boilers No 5 and No 6 are within the requirements of process sheet High temperatures were noted at the outlet gas downstream of the boilers and the economizer The increased temperature downstream of the boiler can result from contamination of its surface as it utilizes fuel oil The outlet gas temperature downstream of economizer is 250°C to 258°C compared with 145°C required by the process sheet It might possibly be caused by the accepted process scheme of the boiler house under which the feed water from de-aerator at 102-104°C is sent to the economizer, the contamination of the inner and the outer surfaces of the boiler It is recommended to check the performance of the economizer Usually water from the economizer is cooled in a heat exchanger to 70-80°C with the water from chemical treatment to the de-aerator Due to a lower temperature, the stable performance of the feed pumps is provided and their service life is extended In our case, the pumps wear out within two years Besides, lower temperature of the water to the economizer decreases the temperature of outlet gas to 120-140°C To increase the boilers efficiency to 90% and to extend the service life of the feed pumps, it is recommended to cool the water from de-aerator This will increase the efficiency by 2% and provide a saving of 150 t of conventional fuel

5 2 Compressor station and cellular concrete shop

Data-loggers were installed on the basic power consuming equipment with the purpose of analysis of the efficiency of the power consumption by separate production areas, as well as analysis of the development of the work schedule of this equipment within a day and within a week Data-loggers recoided the power consumed and power factor (cos φ) for the cellular concrete shop, the compressor station, the steam boiler house, the administrative and the utility building during 5 days from April 10 till April 14, including the weekend April 12 and 13 The digital data on the amount of consumed active power, reactive and full power and cos φ is shown in Appendix 1

The analysis of compressor station performance reveals that during the period of inspection the load was nearly similar and corresponded to performance of one compressor of 63 m^3/min total capacity Only on April 14 from 11 30 till 12 30 two compressors were operated which indicates the use of pneumatic screw pumps for cement handling (refer to Figure 5 3)

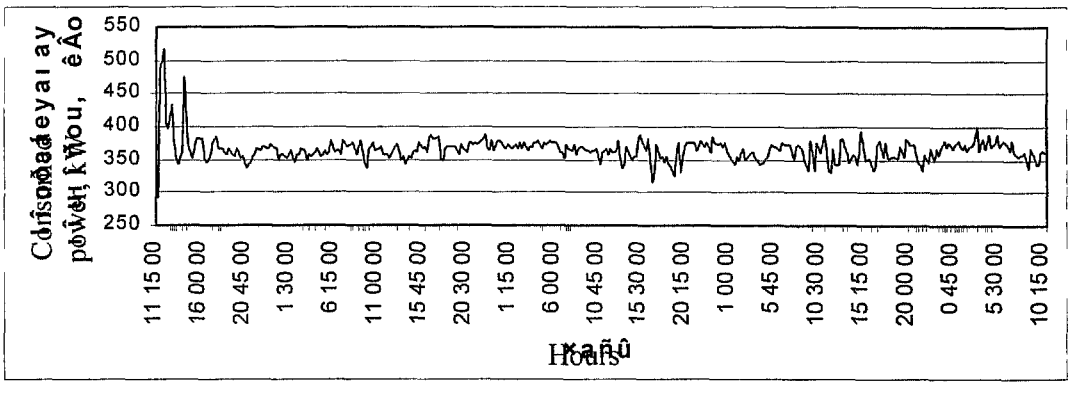
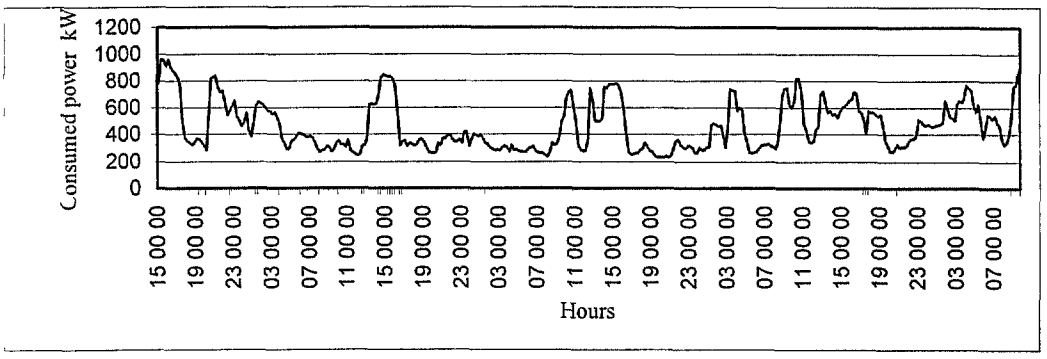
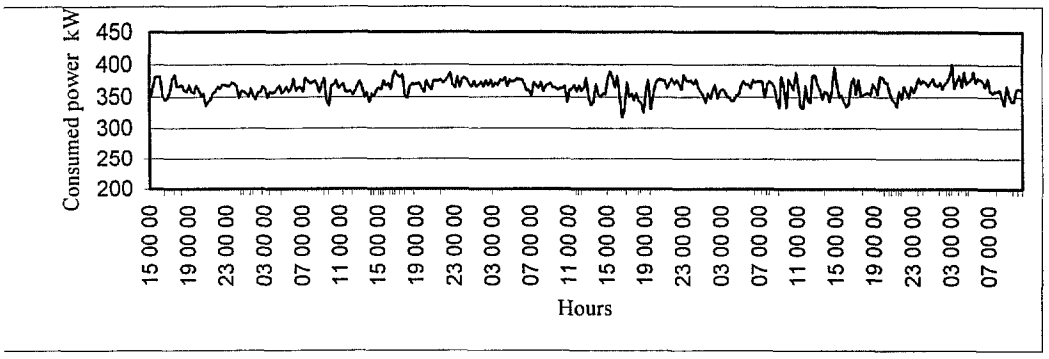


Figure 5 3 Loads on air compressor station

The loads charts for the cellular concrete shop and respective loads for the compressor station from April 10 till April 14 are shown on Figure 5 4 The cos φ for the electric drive of cellular concrete shop has a high value from 0 86 to 0 98 The peaks of the consumption chart correspond to the period of the ball mills performance, which are operated during night hours and weekend Simultaneously with the ball mills, two expander tube pumps (TA 23 B) are operated that transport lime and sand with compressed air





5 4 Load charts for cellular concrete shop and compressor station

It should be noted that during weekend and night hours the only compressed air consumers are the mills of the cellular concrete shop A comparison of the load charts for the compressor station and the cellular concrete shop reveals that during weekend and night hours when the mills are stopped, they do not switch to compressors of lower capacity (20 m^3/min) So, from 17 00 on April 11 till 09 00 AM on April 12 (Saturday) or from 16 00 on April 12 till 02 00 AM on April 13 only the cellular concrete shop were in operation According to the load chart, the mills were switched off, i e there were no compressed air consumers However, the load at the compressor station did not change The power consumption within this period (16 + 10 hours) according to the load chart was

$$E = 380 \times 26 = 9{,}880 \text{ kWh or } 2{,}668 \text{ rubles}$$

During other days of the week, compressed air was consumed for cement pumping and unloading, for pneumatic control of welding machines, for pneumatic tools and instruments, pneumatic cylinders of mixers and for other minor needs The specification of basic compressed air consumers is given in Table 5 2

Table 5 2
Specification of basic compressed air consumers

No	Compressed air consumer	Unit	Number	Required pressure, atm	Certified air consumption, m^3/min
1	Cement transportation to mixers of high-density concrete shop	Pneumatic screw pump NPV-63	1	2	22
2	Cement unloading from rail cars	Pneumatic expander tube pump TA-15	1	6	12
3	TOO Terminal	Pneumatic screw pump NPV-63	1	1	10
4	TOO Terminal	Pneumatic screw pump NPV-110	1	1	19
5	Pneumatic transportation of ground lime and sand	Pneumatic expander tube pump TA-23B	2	6	up to 19

All compressed air consumers mentioned above, with the exclusion of the pneumatic expander tube pumps at the cellular concrete shop which operate from time to time For example, cement transportation to the mixers of the high-density concrete shop takes only 1 hour a day The compressor station works in continuous mode On one hand it results from a large extension and complicated network of compressed air lines (refer to Appendix 3) In the winter, condensate gets frozen in the lines due to the lack of air drier This also results in impossibility of sectioning of the compressed air consumers (shutting down of non-used sections) Due to the operational conditions of the plant, there was no possibility to record actual leaks of compressed air According to the data of other plants, leaks exceed 30% Losses are mostly observed at the sites of consumption due to wear of hoses, leaks of pneumatic cylinders, low reliability of valves Below is a list of area where compressed air is supplied by main pipeline

- cement storage,
- high-density concrete shop,
- cellular concrete shop,
- boiler house,
- garage,
- repair shop,
- facing tile shop

To reduce the compressed air losses, which are mostly observed at sites of consumption due to wear of hoses, leaks of pneumatic cylinders, low reliability of valves, etc , and to reduce non-productive electric power consumption by the compressor station, it is recommended to cut of minor consumers (boiler house, garage, repair shop, facing tile shop) and to install small compressors of 1-2 m^3/min capacity at those locations This will result in considerable reduction of the compressor station capacity During the study of loads on the basic consumer, the cellular concrete shop (5 days), the mills were not performing for 45 h that comprises 240 h per month The cement unloading took place only once (operation of two compressors) Under such conditions one compressor is sufficient for simultaneous cement unloading and mills operation The electric power saving can be approximately evaluated as follows

$$Ec = 240 \times 380 \times 12 = 1{,}094 \text{ thousand kWh or } 295 \text{ thousand rubles}$$

An air drier should also be installed at compressor station

5 3 Steam boiler house

Load chart for a steam boiler house is shown on Figure 5 5

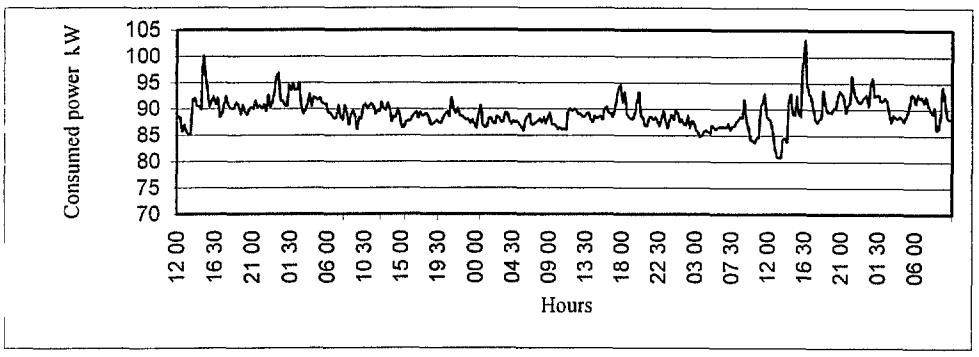


Figure 5 5 Load chart for a steam boiler house

The above data reveals that the load level on the steam boilers is low, varying within 85-100 kW, if two DKVR-10/13 boilers are in operation and it is not critical for a load parameters for the entire plant (refer to Figure 5 7)

5 4 Administrative building

The load charts for administrative building were plotted for evaluation of the power consumption in daily plant consumption balance (refer to Figure 5 6) The data reveal that within the day time hours, the power consumption achieves 10 to 12 kW Lighting system consists of 77 fluorescent and 20 incandescent lamps of total capacity 9 94 kW and 2 5 kW, respectively

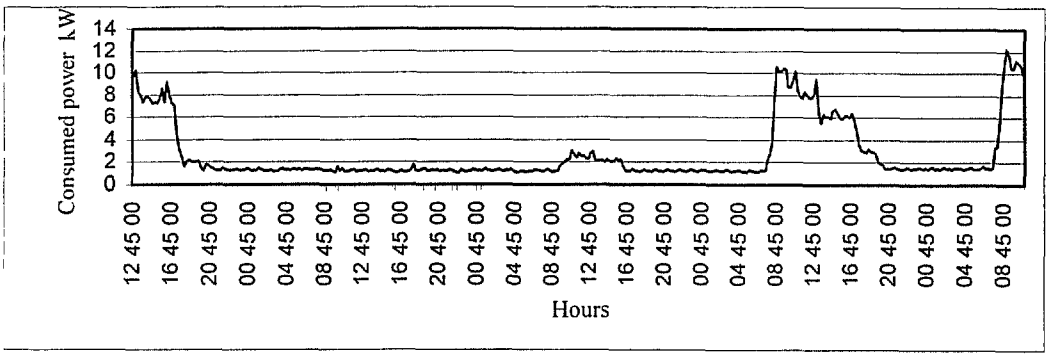


Figure 5 6 Electric load chart for administrative building

In the daily power consumption balance of the plant (34,968 kWh) the share of Administrative building is 1 2% (403 kWh)

5 5 Daily load chart of the plant

For analysis of the daily consumption of active power by separate areas and for the entire plant the hourly power consumption by the entire plant was recorded from April 13 till April 14 As a result the areas, of critical importance were identified It is necessary to understand which equipment influences the amount of consumed capacity at the hours of maximum load The installation of automatic system of metering of the electric power consumption will result in possibilities of monitoring of the power consumed The latter will make it possible to reduce the amount of the declared capacity by 5-15% The load charts for a plant and for separate areas are shown on Figure 5 7

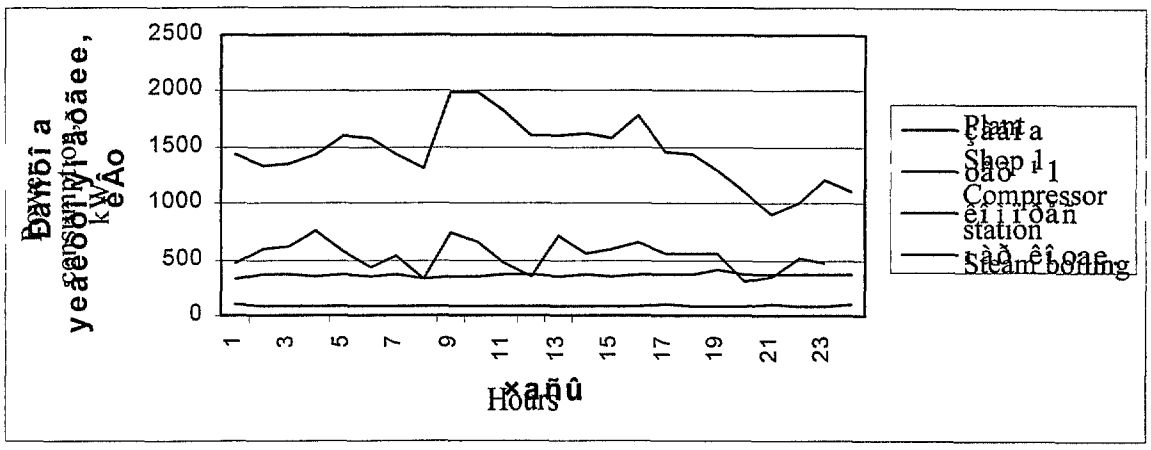


Figure 5 7 Daily load charts from April 13 till April 14, 1998

The data reveal that the load chart profile is a function of loads for the cellular concrete shop To reduce the consumed capacity during the hours of maximum load from 10 00 till 11 00 AM it is recommended to shift the time of ball mills performance to later hours (for example, after 11 00 AM) It will result in reduction of consumed capacity approximately by 400 kW with yearly saving as follows

$$Em = 400 \times 69\ 1 \times 12 = 332 \text{ thousand rubles}$$

5 6 Study of electric drive efficiency

The consumed capacity and cos φ for motors of the basic power consuming equipment were determined to study the efficiency of electric drive use The results are shown in Table 5 3

Table 5 3
Parameters of electric drive of basic equipment

No	Equipment	Established capacity, kW	Consumed capacity				Cos φ	Kз	Notes
			ph 1	ph 2	ph 3	total			
	Steam boiler house								
1	Smoke extractor No 5	55	3 6	3 9	3 6	11 1	0 37	0 20	Air pressure 0 5 kPa
2	Blower No 5	22	1 5	1 8	1 8	5 1	0 37	0 23	Air pressure 0 5 kPa
3	Smoke extractor No 6	55	3 4	3 8	3 6	10 8	0 44	0 20	Air pressure 0 38 kPa
4	Blower No 6	28	3 1	2 1	2 8	8	0 42	0 29	Air pressure 0 38 kPa
5	Feed pump	55	15 4	15 4	13 6	44 4	0 89	0 81	
	Water boiler house								
6	Network pump No 1	200	60	61	63	184	0 89	0 92	
7	GVS pump	15	4 6	4 4	4 3	13 3	0 88	0 89	
8	Smoke extractor No 4	55	7 6	8 2	7 6	23 4	0 46	0 43	
9	Blower No 4	75	10 6	10	10 2	30 8	0 64	0 41	
	Cellular concrete shop (Shop No 1)								
10	Mill No 2	125	36	35	37	108	0 83	0 86	

No	Equipment	Established capacity, kW	Consumed capacity				Cos φ	Kз	Notes
			ph 1	ph 2	ph 3	total			
11	Mill No 5	125	25	25	25	75	0 8	0 60	
12	Mill No 6	125	36	35	37	108	0 83	0 86	
13	Inlet fan P2	14	3 8	3 4	4 2	11 4	0 5	0 81	
14	Inlet fan P3	14	0 6	0 6	0 6	1 8	0 36	0 13	
15	Inlet fan (mill section)	14	3 3	1 5	3 2	8	0 54	0 57	
16	Exhaust fan	7 5	1 7	1 8	1 8	5 3	0 6	0 71	
17	Exhaust fan (mill section)	11	2 5	2 6	2 5	7 6	0 72	0 69	
18	Exhaust fan (reloading conveyer)	1 5	0 55	0 34	0 35	1 24	0 85	0 57	
	High-density concrete shop								
19	Heat screen	17 5	3 1	3 1	3	9 2	0 59	0 53	
20	Inlet fan P8	11	0 9	0 7	0 85	2 45	0 3	0 22	
21	Inlet fan P7	22	2 4	2 7	2 4	7 5	0 42	0 34	
22	Inlet fan P12	28	3 5	3 5	3 5	10 5	0 67	0 38	
23	Inlet fan P11	11	0 66	0 66	0 66	1 98	0 6	0 18	
24	Inlet fan P15	11	0 92	1	1	2 92	0 29	0 27	
25	Inlet fan P16	22	3 5	3 5	3 5	10 5	0 55	0 48	
26	Inlet fan P14	15	3	3	3	9	0 58	0 60	
27	Inlet fan P13	15	2 2	2 2	2 2	6 6	0 46	0 44	
28	Inlet fan P20	15	1 9	1 9	1 9	6 7	0 52	0 45	
29	Heat screen P19	15	1 9	1 9	1 9	6 7	0 46	0 45	
30	Heat screen (first spacing)	7 5	1 37	1 23	1 37	3 97	0 65	0 53	
31	Inlet fan БСО	2 2	0 45	0 45	0 45	1 35	0 55	0 61	
32	Vibrator table	40	7 5	7 5	7 5	22 5	0 75	0 56	
33	Mixer	37	14 2	12	12	38 2	0 84	1 03	Very hard concrete
34	Aspiration fan								mixes
	mixer	5 5	0 99	1	1	2 9	0 68	0 53	
35	Main conveyer	55	8 8	7	6	21 8	0 84	0 40	
36	Conveyer No 5	16	1 5	1 7	1 3	4 5	0 34	0 28	
37	Conveyer No 6	11	0 6	0 6	0 45	1 65	0 2	0 15	
38	Pneumatic screw pump NPV-63	55	13	15	15	43	0 82	0 78	
39	Aspiration fan cement storage	15	2 5	2 6	2 3	7 4	0 7	0 49	
40	Shop lighting	—	—	—	—	116 3	—	—	

The above data reveals that there are a considerable number of electric motors which have a low values of load factor and cos φ, that mainly refers to fans and conveyers Low cos φ values are indicative of low efficiency of electric motors and increased consumption of reactive power The average weighted value of cos φ is 0 59 The losses in motors can be estimated with the help of chart [3]

$$\Delta P = P_2 \times (1 - \eta) = 0{,}3 \times (1 - 0{,}82) = 4{,}8\ \%,$$

Where
P_2 — effective output on the shaft, relative values
η — efficiency of the motor

The norm value of power losses at motors is 1% At annual power consumption of 16,842 thousand kWh the excessive electric power losses will be

$$P = 16{,}842 \times (4{,}8 - 1) = 640 \text{ thousand kWh or } 4{,}547 \text{ thousand rubles}$$

It should be noted that motors with K3 below 0 45 are to be replaced with smaller motors

6 ENERGY SAVING PROJECTS

Project 1

Load optimization of steam-cure units at high-density concrete production

1	Project task	Saving of heat energy
2	Project description	Evaluation of heat specific consumption for high-density concrete production reveals that the decrease of output volume considerably increases heat consumption per one unit of commercial product It results from the fact that at productivity reduction the load on steam-curing units and steam-curing chambers in particular reduces as well, and steam is used inefficiently Due to unstable operation and large number of applied regimes of concrete steam curing a filling-in factor may have a low value At standard capacity load steam specific consumption excluding filler heating is 300 MCal/m^3 that complies with the industry standard values Steam overrate consumption shown in Appendix 3 is 5600 GCal or 896 tons of standard fuel, i e 896/1 13 × 284 1 = 225 thousand Rubles To eliminate these losses it is necessary to monitor steam-curing chambers filling with the purpose to achieve its maximum value
3	Expenditures	None
4	Savings	225 thousand Rubles
5	Payback time	None

Project 2

Optimization of mills operation schedule at cellular concrete shop

1	Project task	Requested capacity reduction at maximum load hours
2	Project description	Daily load character for the entire plant is a function of loads on cellular concrete shop, and of lime and sand mills operation schedules in particular As of the profile of the daily load chart, the installation of automatic metering system of electric power consumption will result in possibility of consumed power monitoring with subsequent reduction of the requested capacity by 5-15% To reduce power consumption during maximum load hours from 10 00 till 11 00 AM it seems sound to shift ball mills operation schedule to later hours (e g after 11 00 AM) It will permit to reduce power consumption by 400 kW with annual saving of Em = 400×69 1×12 = 322 thousand Rubles
3	Expenditures	None
4	Savings	400 kW or 332 thousand Rubles
5	Payback time	None

Project 3

Optimization of operation of pit lime furnaces

1	Project task	Fuel consumption reduction
2	Project description	Actual specific gas consumption at lime production as a function of its output volume varies from 100 to 200 kg of standard fuel per 1 t of lime The increase of specific fuel consumption with lime production decrease results from unstable limestone supply and consequently pit furnaces are not filled to a required level As a result stack gas temperature increases The norm of fuel consumption for lime burning in pit furnaces is 120 kg of standard fuel per 1 t of lime Fuel overrate consumption as to compare with the industry standards is 73 tons of standard fuel per 1 t or in cash it is 73/1 13×284 1 = 18 thousand Rubles
3	Expenditures	None
4	Savings	18 thousand Rubles
5	Payback time	None

Project 4

Utilization of steam of unloaded autoclaves

1	Project task	Reduction of heat consumption
2	Project description	Specific steam consumption for cellular concrete production varies from 450 to 500 MCal/m^3 depending on output volume Specific heat consumption for is a low function of output volume The data reveal that autoclaves in which concrete steam-curing takes place are operated at full load The average industry values of specific steam consumption for cellular concrete production vary within 250-350 MCal/m^3 Steam overrate consumption results from the lack of steam relief from the unloaded autoclaves to the loaded ones due to unstable operations Autoclave steam pressure is kept at 8 atm level Steam relieved from autoclave at a pressure drop to 3 atm heats water that is used for greenhouse heating Note that such steam utilization is of seasonal character At a pressure drop below 3 atm the water head prevents bubbling and steam is discharged to atmosphere Note that steam downstream of autoclave is contaminated with oils and paraffin So steam relief results not only in heat losses but in environmental impact as well To eliminate these negative effect spent steam should be used for water heating in pipe heat exchangers for the hot water supply system that is being constructed at water boiler house Besides steam will be completely condensed and discharged to a sewage system resulting both in heat utilization and environmental impact elimination Specific heat consumption will be reduced to the average industry standards The efficiency of this program implementation will result in approximately 3,000 GCal/year (calculations are shown in Appendix 4), 7,800 GCal or 1,248 tons of standard fuel In cash it comprises 1248/1 13×284 1 = 314 thousand Rubles
3	Expenditures	300 thousand Rubles
4	Savings	314 thousand Rubles
5	Payback time	11 months

Project 5

Condensate drums installation at facing tile shop

1	Project task	Reduction of heat consumption
2	Project description	Inspection of steam supply system in facing tile shop (April of 1998) revealed that condensate line was cut and spent steam was discharged to atmosphere Besides, temperature drop between shop inlet and condensate line was 30°C Due to a lack of a condensate drum no steam condensation takes place and, consequently, hidden evaporation heat (r=510 kcal/kg) is not utilized Only the heat of steam cooling is used (about 30 kcal/kg) Even if the obtained steam-condensate mix is sent back to a boiler house after condensate line repair, the actual heat losses with the straight steam with regard to necessity of its cooling to 80°C will comprise about 400 kcal/kg or 78% of steam supplied to a facing tile shop Specific steam consumption under plant standards will be 15 MCal/m^2, at annual output of 29,948 m^2 of tile in 1997 yearly steam consumption will comprise Q2 = 29,948×0 015 = 449 GCal Actual steam consumption with regard to the above calculations of losses can achieve Qф = 800 GCal with steam overrate consumption of 351 GCal Losses of chemically treated water are 1330 t To avoid them it is necessary to install a condensate drum and condensate line repair Saving will comprise 351 GCal or 56 t of standard fuel In cash Heat 56/1 13×284 1 = 14 thousand Rubles Water 1330×33 2 = 44 thousand Rubles
3	Expenditures	2 thousand Rubles (condensate drum price is $300)
4	Savings	60 thousand Rubles
5	Payback time	1 month

Project 7

Conversion of cellular concrete shop heating system from steam to water

1	Project task	Reduction of heat consumption
2	Project description	Cellular concrete shop heating system uses steam that implies certain saving reserve in case of its conversion to water Estimated heat consumption for heating is 2,350 GCal with the heat losses in steam system are about 50% due to lack of condensate drum In the event of 30% losses actual heat consumption is about 3,050 GCal at overrate consumption of 700 GCal Conversion to water heating results in possibility of more effective adjustment and saving of 6% of heat or 183 GCal Total saving is 883 GCal is or 141 t of standard fuel Cash saving is 141/1 13×284 1 = 35 thousand Rubles
3	Expenditures	70 thousand Rubles
4	Savings	35 thousand Rubles
5	Payback time	2 years

Project 8

Installation of separate low capacity compressors for small compressed air consumers

1	Project task	Reduction of electric power consumption
2	Project description	It is necessary to eliminate compressed air leaks at working areas resulting from hoses and pneumatic cylinders wear, poor conditions of valves, etc , as well as to reduce waste of electric power for compressor station It would be sound to cut off small compressed air consumers, such as a boiler house, repair shop, facing tile shop and garage and to install separate small compressors of 1-3 m^3/min capacity It will permit to unload compressor station (on the average it is 240 h per month) Under such conditions one compressor will be sufficient for simultaneous unloading of cement and performance of mills Electric power saving can be approximately estimated as follows Eк = 240×380×12 = 1,094 thousand of kW h or 1,094×0 27 = 295 thousand Rubles
3	Expenditures	A price of one FE-180-8 compressor is $10 5 thousand, 4 compressors will make $42 thousand or 260 thousand Rubles
4	Savings	295 thousand Rubles
5	Payback time	1 year

Project 9

Introduction of automatic electric power metering system

1	Project task	Reduction of electric power consumption
2	Project description	Introduction of an automatic electric power metering system will make it possible to monitor power consumption resulting in reduction of the requested capacity by 5-15% (that comprised 1,804 4 thou Rbl in 1997), as well as to introduce night rates for electric power The load variability for the entire plant is a function of loads on cellular concrete shop Application of a night rate will result in following saving for the consumption of March-October of 1997 (at rate of 0 27 Rbl/kWh) Night rate $E_T = (1{,}780 + 1{,}786 + 1{,}541 + 1{,}394 + 1{,}722 + 1{,}927) \times 103 \times 0\ 27 \times 0\ 04 = 110$ thou Rubles Monitoring $1{,}804\ 4 \times 0\ 05 = 90$ thou Rbl
3	Expenditures	500 thousand Rubles
4	Savings	200 thousand Rubles
5	Payback time	2 5 years

Project 10

1	Project task	Reduction of heat and electric power consumption
2	Project description	The plant has a large production area and steam and compressed air lines length resulting in considerable energy losses In winter due to unstable operation condensate lines get periodically frozen and pressure must be kept in compressed air lines regardless of its utilization So it seems sound to locate sources of steam and compressed air closer to consumers Cellular concrete shop re-equipment provides for installation of a mini-boiler house with steam production capacity of 7 t/h at autoclave area It will reduce specific fuel and electric power consumption for steam production, heat losses and will make it possible to use higher pressure in the course of autoclave treatment It will result in to improve strength parameters of concrete, to increase loading of autoclaves and to reduce specific steam consumption per unit of commercial production Steam consumption in a cellular concrete shop is 26,442 GCal or 4,321 tons of standard fuel Installation of a separate boiler is supposed to increase efficiency from 87% to 92%, to eliminate losses in the network (347 GCal or 56 tons of standard fuel) It will also reduce expenditures on steam boiler house operations by 30% (mean monthly expenditure on operation in the first quarter of 1998 is 138 5 thou Rbl) Steam for high-density concrete shop and facing tile shop can be produced at water boiling-house with two steam boilers currently not more than 50% of these boilers capacity is used Cash saving Fuel 4,231/1 13 × 0 05 × 284 1 = 60 thou Rbl Losses 56/1 13 × 284 1 = 14 thou Rbl Operations 138 5 × 12 × 0 3 = 500 thou Rbl
3	Expenditures	600 thou DM or 2 mln Rbl
4	Savings	574 thou Rbl
5	Payback time	3 5 years

7 APPENDICES

Appendix 2

Table 1
Specification of flow meters of consumed gas and produced steam

No	Month	Steam boiler house			Water boiler house		
		Steam production, GCal	Fuel consumption, t of conventional fuel	Specific consumption, kg of standard fuel per 1 GCal	Heat production, GCal	Fuel consumption, t of conventional fuel	Specific consumption, kg of standard fuel per 1 GCal
1	January	3,340	480	143 7	14,990	2,120	141 4
2	February	3,030	440	145 2	11,390	1,610	141 4
3	March	2,810	405	144 1	9,870	1,395	141 3
4	April	2 975	425	142 9	7 910	1,125	142 2
5	May	2,040	290	142 2	3,230	460	142 4
6	June	2,220	320	144 1	1,150	160	139 1
7	July	3,620	515	142 3	980	135	137 8
8	August	3,980	510	128 1	1,280	180	140 6
9	September	3,820	540	141 4	2,030	290	141 5
10	October	4,300	533	124 4	3,930	833	140 8
11	November	3,790	402	106 1	11 600	1,640	141 4
12	December	4 640	675	145 5	14,380	2,033	141 5
13	Year	40,565	5,537		84,760	11,985	

Specific fuel consumption for heat production at boiler houses in accordance with plant balance is 106-145 kg of standard fuel per 1 GCal at a pre-estimated value of 142 kg of standard fuel per 1 GCal

Appendix 3

Table 1
Specific steam consumption for cellular concrete production

No	Month	Concrete output, thousand m^3	Steam consumption, GCal	Specific steam consumption, MCal/m^3	Steam over-consumption as to compare with norms, GCal
1	January	2,533	1,100	434 3	213
2	February	3,210	1,500	467 3	377
3	March	3,701	1,893	511 5	598
4	April	4,086	2,005	490 7	575
5	May	2,248	1,385	616 1	598
6	June	4,426	1,503	339 6	–46
7	July	6,322	2,970	469 8	757
8	August	7,844	3,215	409 9	470
9	September	6,308	3,457	548 0	1,249
10	October	6,751	3,377	500 2	1,014
11	November	4,083	2,267	555 2	838
12	December	4,798	2 870	598 2	1,191
13	Year	56,310	26,442	469 6	7,834

Table 2
Specific steam consumption for high-density concrete production

No	Month	Concrete output, thousand m^3	Steam consumption, GCal	Specific steam consumption, MCal/m^3	Steam over-consumption as to compare with norms, GCal
1	January	1,482	2,204	1,487	1,759
2	February	1,478	1,482	1,003	1,038
3	March	1,422	877	617	451
4	April	1,283	941	733	556
5	May	788	627	795	390
6	June	1,741	682	392	160
7	July	1,377	603	438	190
8	August	1,805	742	411	200
9	September	264	316	1,196	237
10	October	940	879	935	597
11	November	642	1,485	2,313	—
12	December	533	1,737	3 258	—
13	Year	13,755	12,574	914	5,578

Table 3
Specific steam consumption for lime production

No	Month	Fuel consumption tons of standard fuel	Lime production, t	Fuel specific consumption, kg of standard fuel per 1 standard ton	Fuel over-consumption as to compare with norms, GCal
1	January	250	2,052	122	2 2
2	February	—	—	—	—
3	March	250	2,210	113	0 0
4	April	—	—	—	—
5	May	300	2,220	135 0	6 6
6	June	140	684	204 0	12 7
7	July	200	1,911	105 0	–1 6
8	August	290	2 029	143 0	8 7
9	September	200	1,345	149 0	7 2
10	October	210	1,429	147 0	7 1
11	November	240	1,661	145 0	7 7
12	December	190	826	230 0	22 2
13	Year				73

8 REFERENCES

1 Procedure of calculation of advanced technical and economical norms of heat power consumption at precast concrete production plants 1986

2 Temporary norms on consumption of heat and electric energy at lime-sand brick production, 1987

3 Temporary norms on consumption of fuel and electric energy at lime production, 1983

4 A I Vazhnov Electrical Machines 1969

Приложение 1

Цех ячеистого бетона трансформатор 2

Record Number	Record Date	Record End Time	Chan 1 Avg Volts	Chan 1 Avg Amps	Chan 1 Avg kW	Chan 1 Avg kVA	Chan 1 Avg PF	Chan 1 Avg kVAR	Chan 2 Avg Volts	Chan 2 Avg Amps	Chan 2 Avg kW	Chan 2 Avg kVA	Chan 2 Avg PF	Chan 2 Avg kVAR	Chan 5 Avg kW	Chan 5 Avg kVA	Chan 5 Avg PF	Chan 5 Avg kVAR
1	04 10 98	14 30 00	6030 5	73 06	201 256	440 49	0 46	391 268	6035 2	73 69	443 289	444 656	1	33 627	644 55	772 628	0 83	424 893
2	04 10 98	14 45 00	6040	74 72	209 552	451 142	0 46	398 881	6047 9	73 9	445 479	446 855	1	33 526	655 033	785 41	0 83	432 408
3	04 10 98	15 00 00	6033 6	78 15	219 529	471 336	0 47	415 814	6044 7	78 54	472 288	474 764	0 99	46 274	691 809	832 576	0 83	462 09
4	04 10 98	15 15 00	6054 2	72 74	212 157	440 314	0 48	385 633	6060 6	75 24	453 682	455 918	1	41 646	665 838	791 344	0 84	427 272
5	04 10 98	15 30 00	6092 3	70 08	207 325	426 919	0 49	372 275	6106 6	71 67	436 25	437 589	1	31 65	643 575	760 21	0 85	403 933
6	04 10 98	15 45 00	6124	67 85	204 868	415 473	0 49	361 198	6135 1	69 71	426 586	427 686	1	27 475	631 46	741 773	0 85	388 678
7	04 10 98	16 00 00	6151	68 53	208 997	421 441	0 5	365 835	6165 3	70 83	435 437	436 628	1	30 542	644 428	756 694	0 85	396 373
8	04 10 98	16 15 00	6197	68 87	200 239	426 845	0 47	376 201	6224	69 96	433 958	435 464	1	35 022	634 192	756 239	0 84	411 219
9	04 10 98	16 30 00	6233 5	67 73	204 351	422 18	0 48	369 235	6249 3	68 94	429 201	430 891	1	34 311	633 557	751 37	0 84	403 548
10	04 10 98	16 45 00	6281 1	66 89	200 748	420 129	0 48	368 866	6300 1	68 12	427 658	429 145	1	34 08	628 411	746 639	0 84	402 948
11	04 10 98	17 00 00	6295 3	63 52	192 932	399 962	0 48	350 149	6309 6	64 59	406 17	407 592	1	32 038	599 106	710 799	0 84	382 181
12	04 10 98	17 15 00	6314 4	56 33	181 689	355 618	0 51	305 519	6328 6	57 17	361 318	361 669	1	13 58	543 011	629 888	0 86	319 101
13	04 10 98	17 30 00	6374 6	24 64	80 53	156 875	0 51	134 269	6392 1	24 78	157 66	158 131	1	-0 794	238 188	273 518	0 87	133 473
14	04 10 98	17 45 00	6411 1	13 95	49 84	89 463	0 56	73 869	6431 7	14 17	90 415	91 136	0 99	7 797	140 253	155 453	0 9	66 072
15	04 10 98	18 00 00	6090 7	01 12 1992	49 942	78 71	0 63	60 501	6124	13 61	81 482	83 283	-0 98	15 566	131 425	139 193	0 94	44 937
16	04 10 98	18 15 00	6084 4	13 29	49 748	80 844	0 62	63 365	6111 3	13 63	81 722	83 274	-0 98	14 282	131 469	140 643	0 93	49 079
17	04 10 98	18 30 00	6087 6	13 42	49 332	81 777	0 6	64 788	6114 5	13 47	80 733	82 331	0 98	13 737	130 063	140 212	0 93	51 054
18	04 10 98	18 45 00	6090 7	01 12 1981	49 397	78 054	0 63	60 261	6119 3	01 12 1985	76 724	78 664	0 98	16 592	126 121	133 606	0 94	43 664
19	04 10 98	19 00 00	6089 1	01 12 1967	49 748	77 112	0 65	58 774	6120 9	01 12 1976	75 939	78 137	0 97	18 098	125 683	132 127	0 95	40 682
20	04 10 98	19 15 00	6095 5	01 12 1990	50 376	78 59	0 64	60 076	6122 4	13 06 1998	78 008	79 966	0 98	16 971	128 385	135 529	0 95	43 111
21	04 10 98	19 30 00	6101 8	14 36	51 115	87 634	0 58	70 59	6128 8	13 7	82 498	84 013	0 98	12 952	133 611	146 241	0 91	57 642
22	04 0 98	19 45 00	6089 1	13 2	49 129	80 382	0 61	63 116	6116 1	01 12 1992	77 084	79 024	0 98	15 881	126 21	135 33	0 93	47 238
23	04 10 98	20 00 00	6092 [illegible]	13 47	48 113	82 008	0 59	66 201	6124	13 61	82 137	83 301	0 99	13 035	130 249	140 831	0 92	53 164
24	04 10 98	20 15 00	6068 5	38 02	115 774	230 643	0 5	199 316	6093 9	39 11	238 089	238 227	1	3 095	353 861	407 766	0 87	202 406
25	04 10 98	20 30 00	6046 3	70 12	213 737	424	0 5	366 011	6070 1	72 6	440 093	440 739	1	21 728	653 833	760 268	0 86	387 744
26	04 10 98	20 45 00	6046 3	71 05	213 589	429 626	0 5	3[illegible]2 598	6068 5	73 31	444 287	444 878	1	20 5	657 87	766 416	0 86	393 09
27	04 10 98	21 00 00	6043 1	70 14	210 124	423 916	0 5	368 034	6066 9	72 26	437 931	438 421	1	18 513	648 055	754 647	0 86	386 552
28	04 10 98	21 15 00	60[illegible]4 2	58 47	179 315	353 946	0 51	304 992	6078	61 2	371 748	371 96	1	9 284	551 063	634 508	0 87	314 28
29	04 10 98	21 30 00	60[illegible]4	53 67	163 342	325 169	0 5	281 047	6086	55 95	340 329	340 458	1	7 529	503 666	580 507	0 87	288 581
30	04 10 98	21 45 00	6043 1	53 49	164 293	323 145	0 51	278 155	6070 1	55 29	335 58	335 663	1	5 257	499 867	574 646	0 87	283 407
31	04 10 98	22 00 00	6055 8	46 91	146 122	284 068	0 51	243 465	6084 4	48 64	295 828	295 902	1	0 37	441 943	504 769	0 88	243 837

42

32	04 10 98	22 15 00	6066 9	38	114 508	230 467	0 5	199 907	6095 5	39 66	241 71	241 784	1	-4 093	356 216	406 5	0 88	195 818
33	04 10 98	22 30 00	6066 9	38 09	118 259	231 058	0 51	198 373	6093 9	39 36	239 798	239 881	1	3 972	358 063	407 449	0 88	194 408
34	04 10 98	22 45 00	6065 3	44 37	136 523	269 102	0 51	231 751	6087 6	46 44	282 682	282 774	1	3 067	419 207	480 513	0 87	234 812
35	04 10 98	23 00 00	6068 9	47 19	141 826	286 275	0 5	248 436	6090 7	48 8	296 909	297 204	1	8 97	438 74	508 934	0 86	257 399
36	04 10 98	23 15 00	6079 6	35 95	106 416	218 494	0 49	190 613	6108 2	36 49	222 753	222 901	1	4 296	329 167	382 755	0 86	194 911
37	04 10 98	23 30 00	6092 3	33 17	100 392	202 059	0 5	175 019	6119 3	33 72	205 939	206 263	1	0 36	306 335	353 446	0 87	175 379
38	04 10 98	23 45 00	6111 3	28 46	95 782	173 947	0 55	145 124	6132	29 05 1998	177 643	178 114	1	12 241	273 42	304 019	0 9	132 885
39	04 11 98	0 00 00	6116 1	31 49	104 208	192 572	0 54	161 845	6143 1	32 03	196 424	196 766	1	10 448	300 626	336 627	0 89	151 4
40	04 11 98	0 15 00	6117 7	37 93	124 772	232 038	0 54	195 491	6141 5	38 34	235 243	235 382	1	7 206	360 021	406 296	0 89	188 289
41	04 11 98	0 30 00	6132	23 16	80 096	141 992	0 56	117 095	6155 8	23 59	143 932	145 133	-0 99	15 77	224 026	246 139	0 91	101 32
42	04 11 98	0 45 00	6133 6	19 09 1998	66 968	117 104	0 57	95 939	6160 5	19 57	119 137	120 522	0 99	17 867	186 102	201 862	0 92	78 073
43	04 11 98	1 00 00	6125 6	31 17	96 263	190 816	0 5	164 626	6147 8	31 83	195 454	195 62	1	3 926	291 723	333 145	0 88	160 7
44	04 11 98	1 15 00	6111 3	42 96	130 25	262 542	0 5	227 843	6132	44 16	270 681	270 737	1	3 178	400 929	462 743	0 87	231 021
45	04 11 98	1 30 00	6109 8	44 57	134 371	272 279	0 49	236 629	6133 6	45 84	281 074	281 167	1	3 298	415 442	479 816	0 87	239 926
46	04 11 98	1 45 00	6111 3	43 39	126 139	265 092	0 48	232 897	6132	44 59	273 194	273 48	1	7 825	399 336	466 576	0 86	240 718
47	04 11 98	2 00 00	6120 9	40 93	119 959	250 523	0 48	219 677	6141 5	42 32	259 725	259 9	1	4 906	379 685	441 288	0 86	224 577
48	04 11 98	2 15 00	6119 3	40 04	118 601	244 99	0 48	214 208	6143 1	40 68	249 71	249 895	1	4 647	368 309	428 589	0 86	218 848
49	04 11 98	2 30 00	6127 2	39	113 806	238 985	0 48	209 94	6147 8	40 45	248 352	248 593	1	6 171	362 167	421 974	0 86	216 117
50	04 11 98	2 45 00	6128 8	37 45	114 785	229 562	0 5	198 678	6147 8	38 2	234 846	234 874	1	0 647	349 637	401 836	0 87	198 03
51	04 11 98	3 00 00	6136 7	35 2	110 813	215 954	0 51	185 218	6154 2	36 22	222 781	222 929	1	-6 18	333 59	378 619	0 88	179 038
52	04 11 98	3 15 00	6133 6	36 52	113 991	223 908	0 51	192 489	6152 6	37 13	228 379	228 527	1	5 432	342 374	390 295	0 88	187 054
53	04 11 98	3 30 00	6144 7	35 13	111 035	215 797	0 51	184 858	6168 4	36 13	222 531	222 781	1	7 843	333 567	377 766	0 88	177 014
54	04 11 98	3 45 00	6147 8	27 03 1998	92 235	166 049	0 56	137 816	6170	27 89	170 501	172 007	0 99	18 319	262 735	289 126	0 91	119 5
55	04 11 98	4 00 00	61 2 6	16 36	60 372	100 642	0 6	80 401	6171 6	17 13	102 942	105 695	0 97	23 308	163 307	173 085	0 94	57 092
56	04 11 98	4 15 00	6102 1	19 91	72 197	122 62	0 59	98 905	6187 5	20 68	125 696	127 95	0 98	2 95	197 895	212 62	0 93	76 947
57	04 11 98	4 30 00	6102 1	15 45	58 257	95 256	0 61	75 227	6185 9	16 04 1998	96 318	99 293	0 97	23 899	154 574	162 885	0 95	51 327
58	04 11 98	4 45 00	6151	15 45	58 765	95 062	0 62	74 599	6176 4	16 11 1998	96 494	99 533	0 97	24 149	155 261	163 258	0 95	50 449
59	04 11 98	5 00 00	6146 2	15 56	59 18	95 708	0 62	75 079	6170	16 18	96 678	99 755	0 97	24 287	155 861	163 937	0 95	50 791
60	04 11 98	5 15 00	6147 8	15 43	58 367	94 822	0 62	74 627	6168 4	15 97	95 505	98 582	0 97	24 14	153 876	161 949	0 95	50 479
61	04 11 98	5 30 00	6136 7	15 81	60 16	97 03	0 62	76 012	6162 1	16 38	97 27	100 9	0 96	26 569	157 428	165 022	0 95	49 438
62	04 11 98	5 45 00	6135 1	16 49	63 596	101 261	0 63	78 692	6154 2	16 97	99 884	104 42	0 96	30 218	163 475	170 514	0 96	48 476
63	04 11 98	6 00 00	6141 5	16 24	62 441	99 819	0 63	77 768	6162 1	16 65	98 351	102 665	0 96	29 267	160 795	167 955	0 96	48 5
64	04 11 98	6 15 00	6139 9	16 4	62 811	100 734	0 62	78 636	6163 7	16 81	99 404	103 635	0 96	29 156	162 215	169 603	0 96	49 478
65	04 11 98	6 30 00	6138 3	16 45	61 518	101 03	0 61	79 819	6158 9	16 81	99 94	103 561	-0 96	25 867	161 451	170 644	0 95	53 955
66	04 11 98	6 45 00	61 4 2	16 02 1998	58 118	98 572	0 59	79 237	6179 5	17 43	105 483	107 663	0 98	18 384	163 602	174 995	0 93	60 851
67	04 11 98	7 00 00	6152 6	16 52	60 862	101 658	0 6	81 177	6181 1	17 05 1998	101 935	105 409	-0 97	25 867	162 798	172 227	0 95	55 31

68	04 11 98	7 15 00	6160 5	17 59	61 896	108 383	0 57	88 549	6187 5	18 16	109 326	112 374	-0 97	23 779	171 218	183 639	0 93	64 768
69	04 11 98	7 30 00	6162 1	16 63	58 58	102 434	0 57	83 532	6187 5	17 75	107 09	109 852	-0 97	21 682	165 673	177 607	0 93	61 853
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71	04 11 98	8 00 00	6074 9	13 31	50 737	80 844	0 63	62 811	6098 7	13 56	80 715	82 719	-0 98	17 756	131 445	138 959	0 95	45 056
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197	04 12 98	15 30 00	5995 6	65 82	176 663	394 64	0 45	352 754	6013	67 44	403 066	405 56	0 99	44 297	579 737	702 705	0 83	397 051
198	04 12 98	15 45 00	6017 8	56 83	156 57	341 881	0 46	303 791	6035 2	58 31	350 204	351 747	1	32 214	506 77	608 095	0 83	335 998
199	04 12 98	16 00 00	6033 6	45 57	121 622	274 903	0 44	246 366	6049 5	46 39	279 374	280 585	1	25 257	401 001	484 412	0 83	271 622
200	04 12 98	16 15 00	6047 9	32 67	76 761	197 44	0 39	181 264	6068 5	32 26	193 44	195 657	0 99	27 669	270 204	342 303	0 79	208 941
201	04 12 98	16 30 00	6054 2	19	33 406	114 97	0 29	109 815	6081 2	18 57	110 222	112 864	0 98	23 604	143 630	196 185	0 73	133 418
202	04 12 98	16 45 00	6044 7	18 13	33 729	109 64	0 31	104 198	6068 5	17 91	106 536	108 688	0 98	21 313	140 269	188 242	0 75	125 514
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207	04 12 98	18 00 00	6028 9	19 43	35 53	117 132	0 3	111 487	6049 5	18 97	112 411	114 804	0 98	23 059	147 947	200 002	0 74	134 547
208	04 12 98	18 15 00	6020 9	19 25	35 346	115 82	0 31	110 166	6043 1	18 95	112 263	114 49	0 98	22 089	147 61	198 215	0 74	132 253
209	04 12 98	18 30 00	6027 3	18 25	33 914	109 908	0 31	104 392	6043 1	17 81	105 593	107 69	0 98	20 786	139 509	187 468	0 74	125 184
210	04 12 98	18 45 00	6025 [illegible]	16 88	28 74	101 704	0 28	97 408	6049 5	16 4	96 836	99 247	0 98	21 516	125 57	172 989	0 73	118 93
211	04 12 98	19 00 00	6019 4	16 63	27 438	100 078	0 27	96 115	6043 1	16 15	94 997	97 584	0 97	22 135	122 434	170 241	0 72	118 247

212	04 12 98	19 15 00	6033 6	16 36	27 114	98 655	0 27	94 72	6054 2	15 86	93 39	96 013	0 97	22 089	120 506	167 846	0 72	116 811
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214	04 12 98	19 45 00	6035 2	16 63	28 611	100 42	0 28	96 124	6059	16 2	95 487	98 194	0 97	22 708	124 089	171 826	0 72	118 828
215	04 12 98	20 00 00	6035 2	17 04 1998	29 442	102 887	0 29	98 471	6059	16 52	97 473	100 041	0 97	22 32	126 915	175 229	0 72	120 785
216	04 12 98	20 15 00	6032	16 52	28 214	99 57	0 28	95 339	6059	15 99	94 286	96 872	0 97	21 987	122 499	169 66	0 72	117 331
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220	04 12 98	21 15 00	6020 9	17 86	34 043	107 46	0 32	101 796	6041 6	17 79	106 49	107 561	0 99	14 578	140 53	182 497	0 77	116 374
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222	04 12 98	21 45 00	6001 9	21 52	40 584	129 142	0 31	122 481	6027 3	21 75	129 262	131 045	0 99	21 119	169 85	222 451	0 76	143 593
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224	04 12 98	22 15 00	5994	18 16	36 196	108 873	0 33	102 563	6020 9	18 11 1998	108 226	109 039	0 99	12 98	144 418	184 975	0 78	115 544
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226	04 12 98	22 45 00	5997 1	21 07 1998	38 875	126 324	0 31	120 061	6022 5	20 7	123 072	124 726	0 99	19 992	161 946	214 157	0 76	140 052
227	04 12 98	23 00 00	5997 1	20 57	38 902	123 386	0 32	116 956	6024 1	20 54	122 333	123 774	0 99	18 624	161 229	210 685	0 77	135 584
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229	04 12 98	23 30 00	6017 8	18 06 1998	34 459	108 734	0 32	103 025	6043 1	17 97	107 617	108 55	0 99	13 913	142 076	184 022	0 77	116 942
230	04 12 98	23 45 00	6019 4	18 11 1998	35 189	109 085	0 32	103 127	6043 1	17 97	107 718	108 688	0 99	14 051	142 899	184 814	0 77	117 178
231	04/13/98	0 00 00	6024 1	18 34	35 678	110 48	0 32	104 439	6051 1	18 32	109 991	110 795	0 99	12 915	145 665	187 08	0 78	117 362
232	04/13/98	0 15 00	6035 2	19 66	35 022	118 61	0 3	113 16	6059	19 52	116 532	118 213	0 99	19 548	151 551	201 482	0 75	132 708
233	04/13/98	0 30 00	6036 8	20 86	36 741	125 973	0 29	120 328	6059	20 73	123 571	125 631	0 98	22 264	160 31	214 618	0 75	142 594
234	04/13/98	0 45 00	6038 4	20 93	36 297	126 37	0 29	120 92	6062 2	20 89	124 55	126 583	0 98	22 135	160 853	215 311	0 75	143 056
235	04/13/98	1 00 00	6038 4	20 82	35 318	125 65	0 28	120 449	6055 8	20 68	123 183	125 215	0 98	22 181	158 498	213 255	0 74	142 627
236	04/13/98	1 15 00	6024 1	38 81	92 17	233 83	0 39	214 771	6044 7	39 25	235 493	237 257	0 99	28 38	327 658	408 049	0 8	243 153
237	04/13/98	1 30 00	6028 9	39 22	92 669	236 444	0 39	217 395	6047 9	39 45	236 786	238 606	0 99	28 888	329 45	411 356	0 8	246 288
238	04/13/98	1 45 00	6035 2	39 11	91 339	236 029	0 39	217 543	6055 8	39 25	235 77	237 719	0 99	30 071	327 104	410 267	0 8	247 607
239	04/13/98	2 00 00	6036 8	39 06	91 662	235 798	0 39	217 118	6059	39 25	235 807	237 775	0 99	29 997	327 471	410 27	0 8	247 113
240	04/13/98	2 15 00	6038 4	38 81	89 657	234 403	0 38	216 453	6059	38 97	233 931	236 139	0 99	32 103	323 588	408 041	0 79	248 549
241	04/13/98	2 30 00	6052 7	31 58	68 557	191 094	0 36	177 948	6076 5	31 88	191 519	193 514	0 99	26 846	260 074	331 329	0 78	204 796
242	04/13/98	2 45 00	6057 4	23 84	40 962	144 265	0 28	138 103	6082 8	22 36	134 01	136 034	0 99	22 929	174 976	238 285	0 73	161 024
243	04/13/98	3 00 00	6038 4	40 63	99 274	245 184	0 4	223 936	6059	41 61	250 071	251 946	0 99	29 793	349 34	431 923	0 81	253 727
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245	04/13/98	3 30 00	6030 5	67 96	185 366	409 865	0 45	365 42	6052 7	69 51	418 835	420 692	1	38 653	604 197	726 903	0 83	404 071
246	04/13/98	3 45 00	6027 3	67 37	183 574	406 04	0 45	362 02	6043 1	68 44	411 805	413 588	1	37 572	595 375	717 092	0 83	399 592
247	04/13/98	4 00 00	6044 7	51 65	134 232	312 161	0 43	281 601	6066 9	51 78	312 401	314 083	0 99	31 798	446 634	545 744	0 82	313 399

248	04/13/98	4 15 00	6038 4	54 56	139 202	329 418	0 42	298 387	6060 6	55 22	332 347	334 675	0 99	38 764	471 544	579 721	0 81	337 148
249	04/13/98	4 30 00	6038 4	53 51	135 95	323 192	0 42	293 066	6059	54 49	327 801	330 056	0 99	37 803	463 749	569 759	0 81	330 869
250	04/13/98	4 45 00	6055 8	33 47	79 163	202 697	0 39	186 447	6078	33 92	204 692	206 217	0 99	24 528	283 857	353 722	0 8	210 972
251	04/13/98	5 00 00	6057 4	27 57	62 22	167 065	0 37	154 658	6081 2	27 67	166 908	168 247	0 99	19 918	229 136	288 376	0 79	174 573
252	04/13/98	5 15 00	6059	18 47	35 549	111 922	0 32	106 018	6079 6	18 34	110 453	111 441	0 99	14 513	146 002	189 342	0 77	120 533
253	04/13/98	5 30 00	6055 8	18 34	34 764	111 072	0 31	105 372	6076 5	18 22	109 695	110 702	0 99	14 366	144 464	187 645	0 77	119 736
254	04/13/98	5 45 00	6049 5	18 38	35 309	111 229	0 32	105 372	6073 3	18 27	109 972	110 961	0 99	14 255	145 285	188 22	0 77	119 626
255	04/13/98	6 00 00	6043 1	18 32	35 05	110 638	0 32	104 836	6062 2	18 22	109 483	110 416	0 99	13 904	144 532	187 061	0 77	118 739
256	04/13/98	6 15 00	6028 9	18 32	35 373	110 407	0 32	104 485	6049 5	18 29	109 778	110 656	0 99	13 386	145 152	187 002	0 78	117 87
257	04/13/98	6 30 00	6017 8	18 36	35 53	110 471	0 32	104 485	6041 6	18 34	109 843	110 739	0 99	13 506	145 381	187 248	0 78	117 987
258	04/13/98	6 45 00	6009 8	18 2	34 597	109 39	0 32	103 635	6035 2	18 27	109 307	110 194	0 99	13 497	143 899	185 562	0 78	117 136
259	04/13/98	7 00 00	6001 9	18 61	36 611	111 718	0 33	105 418	6024 1	18 54	111 247	111 774	1	9 783	147 854	187 472	0 79	115 196
260	04/13/98	7 15 00	5982 9	18 82	37 766	112 55	0 34	105 898	6006 7	18 72	112 19	112 522	1	7 926	149 961	188 281	0 8	113 828
261	04/13/98	7 30 00	5990 8	18 88	38 163	113 095	0 34	106 342	6016 2	18 91	113 483	113 806	1	7 465	151 649	189 617	0 8	113 808
262	04/13/98	7 45 00	5984 5	18 93	38 524	113 243	0 34	106 342	6011 4	18 91	113 335	113 668	1	7 825	151 863	190 01	0 8	114 167
263	04/13/98	8 00 00	5971 8	18 11 1998	34 459	108 134	0 32	102 36	6001 9	18 59	110 73	111 506	0 99	12 619	145 186	185 216	0 78	114 981
264	04/13/98	8 15 00	5938 5	19 11 1998	36 824	113 511	0 32	107 284	5968 6	19 61	115 368	116 984	0 99	19 031	152 194	197 792	0 77	126 312
265	04/13/98	8 30 00	5978 1	30 15	63 864	180 728	0 35	168 534	6005 1	30 76	182 696	185 218	0 99	29 165	246 564	316 462	0 78	197 699
266	04/13/98	8 45 00	6011 4	51 46	125 021	309 353	0 4	282 737	6035 2	53 24	317 658	321 159	0 99	46 358	442 677	551 847	0 8	329 095
267	04/13/98	9 00 00	5976 5	60 79	147 156	363 276	0 41	331 876	6000 3	62 77	371 702	376 58	0 99	58 044	518 862	649 276	0 8	389 915
268	04/13/98	9 15 00	5973 4	59 86	143 784	357 623	0 4	327 247	5994	61 16	361 983	366 621	0 99	57 157	505 764	635 447	0 8	384 4
269	04/13/98	9 30 00	5979 7	49 28	106 397	294 627	0 36	274 395	6006 7	50 58	296 456	303 671	0 98	63 384	402 851	526 057	0 77	337 777
270	04/13/98	9 45 00	5981 3	44 39	91 976	265 471	0 35	248 75	6009 8	45 82	269 72	275 356	0 98	54 838	361 698	472 428	0 77	303 591
271	04/13/98	10 00 00	5974 9	43 89	86 175	262 117	0 33	246 422	6008 2	46 07	270 136	276 779	0 98	56 39	356 309	469 213	0 76	302 812
272	04/13/98	10 15 00	5960 7	59 79	134 712	356 339	0 38	329 427	5989 2	62 09	365 383	371 739	0 98	66 793	500 093	638 695	0 78	396 221
273	04/13/98	10 30 00	5952 7	63 7	149 189	379 139	0 39	348 366	5973 4	66 09	389 171	394 871	0 99	65 666	538 355	679 441	0 79	414 027
274	04/13/98	10 45 00	5963 8	63 18	140 311	376 718	0 37	349 317	5986	64 66	380 534	386 908	0 98	68 89	520 839	668 27	0 78	418 208
275	04/13/98	11 00 00	6014 6	33 19	48 381	199 593	0 24	193 412	6040	35 47	205 579	214 171	0 96	58 875	253 965	358 676	0 71	252 287
276	04/13/98	11 15 00	6025 7	30 92	43 226	186 253	0 23	180 867	6049 5	31 49	182 52	190 558	0 96	54 432	225 741	326 308	0 69	235 299
277	04/13/98	11 30 00	6035 2	30 17	44 113	182 086	0 24	176 423	6062 2	31 65	183 555	191 888	0 96	55 291	227 672	325 063	0 7	231 72
278	04/13/98	11 45 00	6047 9	24 89	31 65	150 473	0 21	146 925	6078	25 48	148 339	154 833	0 96	43 771	179 992	262 494	0 69	190 693
279	04/13/98	12 00 00	6066 9	20 54	29 378	124 689	0 24	121 021	6093 9	20 77	122 038	126 629	0 96	33 433	151 415	216 392	0 7	154 458
280	04/13/98	12 15 00	6059	20 5	30 218	124 255	0 24	120 356	6092 3	20 8	121 437	126 684	0 96	35 604	151 657	217 623	0 7	155 952
281	04/13/98	12 30 00	6055 8	24 59	45 147	148 81	0 3	140 967	6089 1	24 94	146 916	151 812	0 97	36 177	192 06	262 229	0 73	177 144
282	04/13/98	12 45 00	6044 7	53 28	135 664	322 111	0 42	291 911	6068 5	54 65	328 661	331 635	0 99	43 743	464 328	573 033	0 81	335 65
283	04/13/98	13 00 00	6028 9	59 15	147 434	356 653	0 41	324 624	6052 7	60 72	363 905	367 563	0 99	51 365	511 342	634 736	0 81	375 986