ENERGY AUDIT

OAO NOVOSIBIRSKMEBEL
NOVOSIBIRSK
RUSSIA

Prepared for

US AGENCY FOR INTERNATIONAL DEVELOPMENT
Washington, D C 20253

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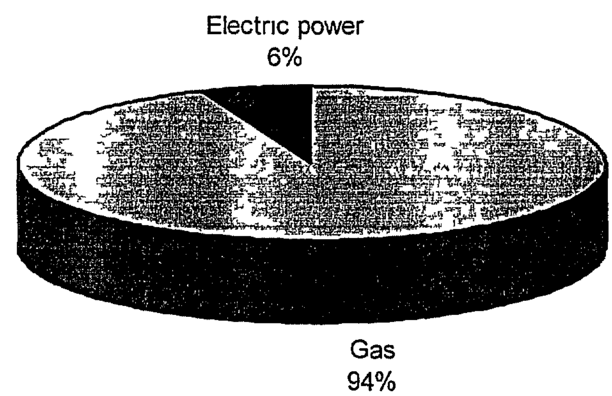
1 EXECUTIVE SUMMARY

This report covers the results of the energy audit of the Open Joint Stock Company "Novosibirskmebel" 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 "Novosibirsk Energo" rendered efficient assistance in the course of the audit

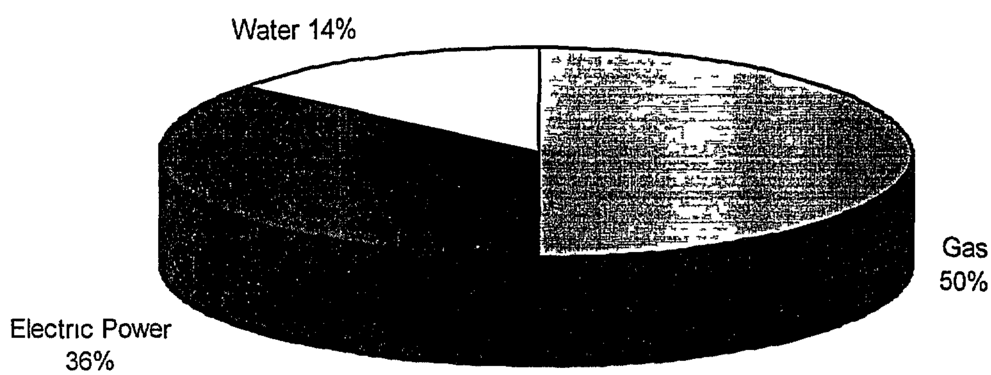
Diagram 1 1 below shows a total energy consumption structure of the company, which represents the share of various utilities consumed by the company The diagram is based on the energy consumption in 1997 According to the diagram, the Furniture Factory "Novosibirskmebel" consumes only 2 types of utilities, namely natural gas and electric power

Diagram 1 1 Energy Consumption Structure



In addition to the above mentioned energy consumption structure, it is important to know the structure of payments for utilities provided in Diagram 1 2 The main expenses are the cost of natural gas - 50%, with electric power bills amounting to 36%, and only 14% - water supply, including water consumption and water drainage

Diagram 1 2 Utilities Payment Structure



The following energy efficiency projects may be recommended according to the results of the energy audit

Table 1 1 Energy efficiency programs

№	Description	Energy savings,		Investments,	Payback period, months
		GJ	rub ($US)	rub ($US)	
No-cost and low cost projects					
1	To use decorative film*	28,438 7	913,230 (144,957)	--	--
2	To use vented-steam from the deaerator to heat treated water	8,306 6	72,353 (11,485)	--	--
3	To reduce vacuum in the furnace of boiler №3	3,626 1	32,336 (5,133)	--	--
4	To replace the HWS pump	7,556 1	81,672 (12,963)	1,800 (286)	1
5	To insulate pipes	8,069 8	71,962 (11,422)	4,800 (761)	1
6	To install the automatic control system at the HWS boiler	7,736 2	89,164 (14,153)	5,000 (794)	1
7	To reduce air suction in boiler №3	3,366 7	30,027 (4,766)	5,000 (794)	2
8	To set-up the recycling water cooling of the air compressors and impregnating lines	--	9,402 (1,492)	9,000 (1,429)	12
9	To use steam-condensate mixture in the dry-kilns	23,645 1	210,856 (33,470)	12,600 (2,000)	1
High cost projects					
10	To install a co-generation turbine	--	7,160,000 (1,137,000)	12,600,000 (2,000,000)	22
TOTAL		**85,219 4**	**7,694,083 (1,221,283)**	**12,638,200 (2,006,063)**	**20**

* The above data corresponds to the production output of furniture with a total finished area of 100 thousand m2 per year

The total amount means an aggregate effect from the implementation of energy efficiency projects taking in to account their interaction (project No 4 and 6) and not considering project No 1

The implementation of the recommended projects would allow to reduce the total energy consumption in 1997 by 23%, in addition, the implementation of project No 10 would cover all costs relating to energy bills payment by revenues obtained through selling generated electric power to the outside clients

Obvious cost-savings expected from the implementation of project No 1 should be also noted

The above list of recommended projects does not include a number of programs, which could be recommended and implemented after additional data is obtained and analyzed Thus and so, the Factory has substantial energy efficiency potential (see Clause 5 2)

2 INTRODUCTION

The energy audit was carried out by a group of engineers of the East-West Energy Agency (Moscow) within the frame work 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 is to analyze the energy use, evaluate their costs and to identify inefficient sectors and to develop a comprehensive energy efficiency program

A great bulk of data on energy usage and process equipment, equipment operation parameters and the current status of distributing energy/utility systems, etc was gathered during the onsite work the company This data was analyzed, systematized and presented in this Report

Data collection was carried out by means of both direct measurements for example, the capacity of power consuming equipment, and calculations based on design and normative documentation as well as information provided by maintenance personnel State-of-the-art portable equipment from Western manufactures was used for direct measurements

3 DESCRIPTION OF THE COMPANY AND TECHNOLOGICAL PROCESS-FLOW

3 1 General description of the Company

The Open Joint Stock Company OAO "Novosibirskmebel" is located in the city of Novosibirsk and is one of the largest furniture factories in this region The Company incorporates 15 divisions, five of which are located in Novosibirsk and ten in the Novosibirsk Region This Report covers only the headquarters of the Company The Company was founded in 1977

The list and volume of goods produced by the Company on a monthly basis in 1997 are provided in Appendix I
Table 3 1 1 provides production dynamics and changes in the amount of staff of the Company for the period of 1994-1997

Table 3 1 1 General Data on the Factory

№	Items	Units	1994	1995	1996	1997
1	*Scope of production and services*	mill rubles	13,088	30,985	27,125	19,472
2	*Basic feed-stock consumption*					
	Particle Boards	м^3	32,818	31,787	20,414	11,302
	Lumber	м^3	16,800	13,300	6,133	2,380
	Finishing materials	thousand m^2	5,001 6	4,491 3	2,669 7	1,735 6
	Varnish	ton	120,900	125,040	105,130	37,853
	Particle hardboards	thousand m^2	401	418	325	140
3	*Basic products output*					
	Furniture sets	set	15,503	10,876	5,952	3,605
	Antechamber furniture sets	set	2,415	4,735	3,098	954
	Shelves	pcs	3,365	4,685	5,117	3,296
	Cabinets	pcs	789	494	1,812	1,657
	Tables	pcs	2,784	35	75	169
4	*Output of additional types of goods*					
	Wood processing	thousand rubles	658,384	989,175	924,169	798,184
	Heating energy	thousand rubles	103,203	246,384	525,256	762,529
	Other commercial goods	thousand rubles	118,480	350,419	636,161	371,259
5	*Average Staff List*	people	491	438	367	295

According to the Table a sharp drop of production has taken place since 1994 It has been caused by a number of reasons, in particular, by ever increasing competition by emerging small business producing various types of furniture and by the availability in the home market of high quality imported goods

Since the Company switched from a three-shift schedule to one shift, the share of energy costs in the production cost has much increased

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

Table 3 1 2 Production Cost Structure per Unit Expenses

№	Expenses	Percentage, %
1	**Material costs, including**	**76 9**
	feed-stock and materials	48 6
	fuel	15 0
	electric power	9 2
	water	4 1
2	**Payroll**	**3 0**
3	**Social security deductions**	**1 6**
4	**Depreciation**	**3 6**
5	**Other expenses**	**14 9**
	TOTAL	**100**

According to the above mentioned Table the share of energy and water costs in the production cost amounts to 28 3%

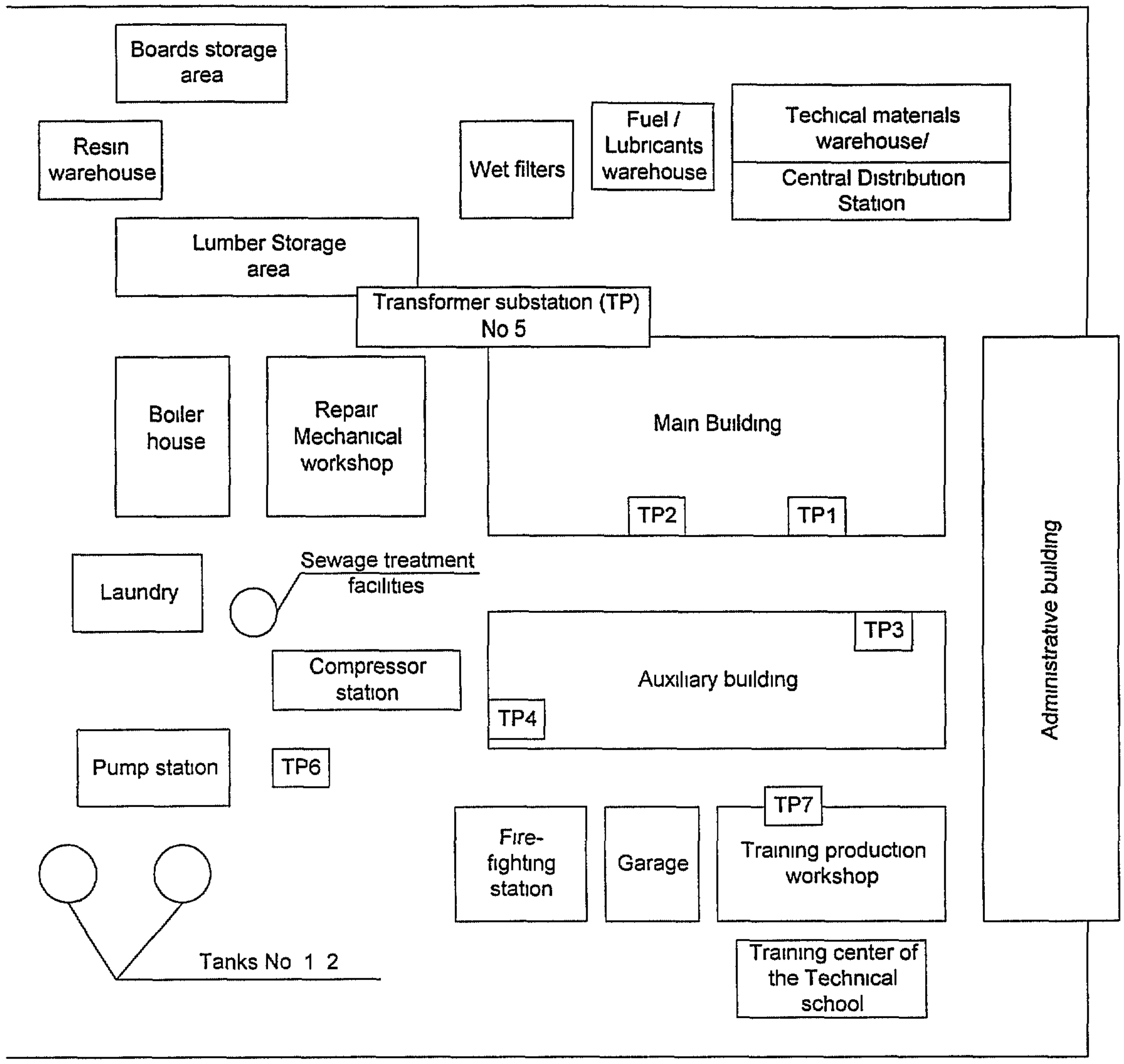
3 2 Description of production

3 2 1 Description of production shops of the Company

The layout of the enterprise (see Fig 3 2 1) shows the location of production shops and basic utility facilities The total area of production site of the headquarters amounts to 16 hectares
The process equipment is primarily located in two buildings the main building (with the volume of about 95,000 m^3) and auxiliary building (with the volume of about 120,000 m^3)

The auxiliary building incorporates Shop No 1 and partially Shop No 3, and the main building - Shops No 2 and 3 Shop No 1 includes the drying section, cutting, pressing and impregnation, Shop No 2 - the section for special orders and basic production section (the molded/shaped boards process line, the filler section, etc), Shop No 3 - finishing lines and varnishing section
At the moment of audit all production sections of the Company were operating one-shift from 8-00 until 15-30

Fig 3 2 1 Layout of the Factory

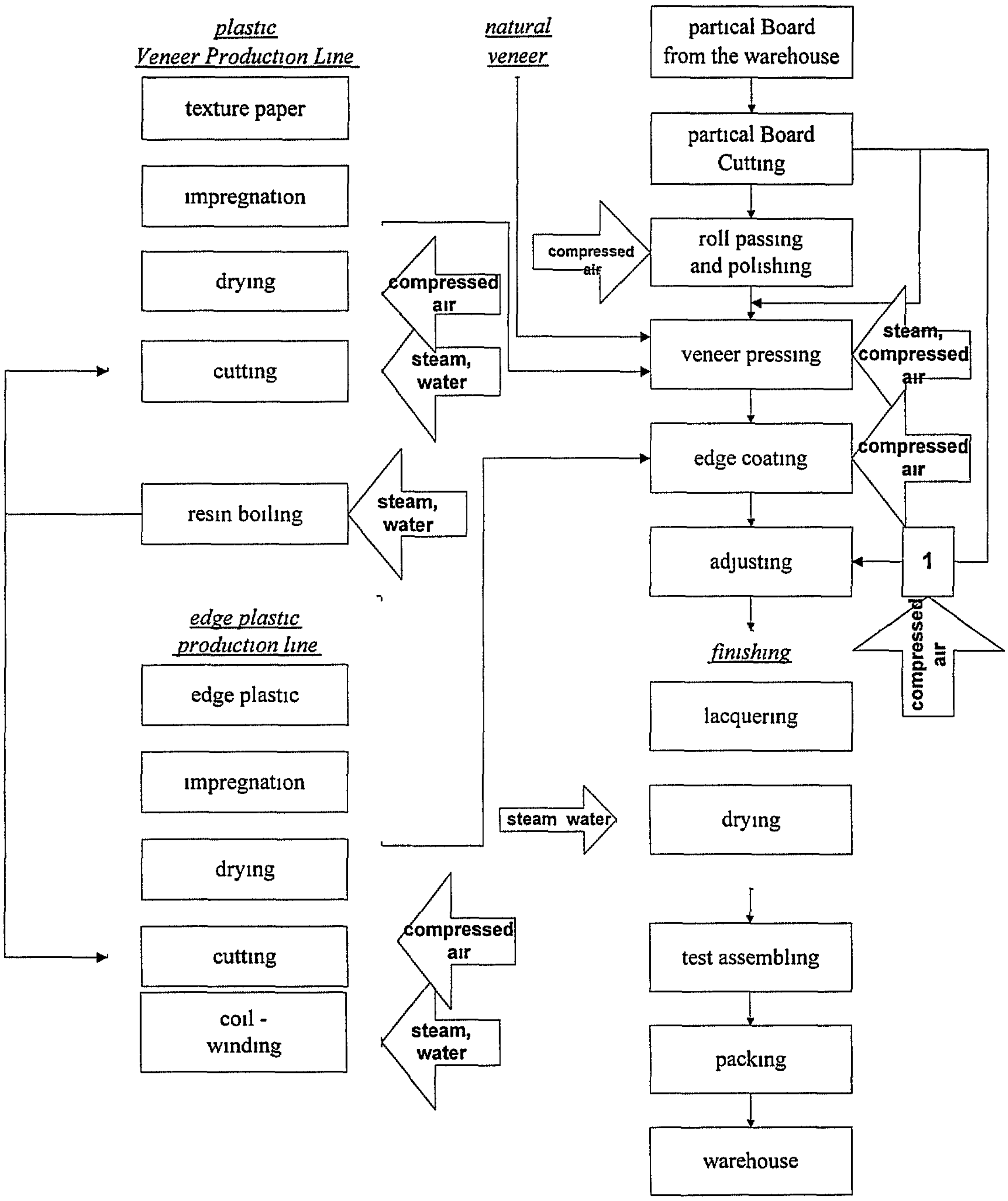


3 2 2 Description of technological process

The Company is supplied with lumber, particleboard (PB), finishing materials and varnishes as basic feedstock

The main technological process of the enterprise is furniture production from natural and plastic veneer (see the process-flow in Fig 3 2 2) Plastic veneer is produced at the Factory, no natural veneer line is available

Fig 3 2 2 Process Flow Diagram



One of the basic types of utilities used in the production of various types of furniture is steam, which is used by many process sections

Textured paper is impregnated by three horizontal impregnating lines KUB-1 with the production capacity of 3-7 m/min Each impregnation line consumes the following amount of utilities steam - 1 7 t/hour, water - 0 37 m^3/hour, compressed air - 0 01 m^3/min and electric power - 48 4 kW/hour

Saturated steam with the pressure of 7-9 atm and temperature 150-170^{0}C is used for drying impregnated paper in a convection drying chamber with automatic temperature control Steam calorifers are finned steel zinc-plated pipes

Process water is used in the process units to cool shafts, finished product and impregnating compound, the temperature of which in the baths and tanks shall be maintained in the range of 28-45^{0}C The water cooling system is of the recycling type and is combined with the recycling water cooling system of compressors The process water is cooled in a cooling tower Presently, the recycling water cooling system is not used and water is discharged into sewer

Edge plastic material is impregnated in the Impregnating Unit A131 with the production capacity of 6-10 m/min operating similar to KUB-1 Units Reactors (with the production capacity of 0 5 tons of compound per hour) are used for impregnating varnish boiling, where the feed-stock is heated up to 60^{0}C by steam

Steam with the temperature of 170^{0}C is used in the Pressing Section for heating veneer and particleboard to pressure-glue layers together (with the duration of pressing about 25-30 seconds) This production section includes two process lines for furniture hardboard veneering, finishing line DXPJA-475 with a hydraulic press and two process lines for the veneering of furniture board parts AKADA with the production capacity of 140 hardboards per hour each Each press consumes 0 4 ton/hour of steam

The enterprise operates two finishing lines MLP with the production capacity of 210 meters per hour and the "Durr" Unit, Canada (with the production capacity of 6,700 m^2/day) which also use steam to dry parts after varnishing

Continuous drying temperature (150^{0}C) should be stringently maintained throughout the entire volume of the drying chamber The chamber is heated by steam passing through thin-wall finned pipes inside the drying chamber

The "Durr" Unit is equipped with steam drying chambers with condensate collectors after which 8 after-drying 11 kW UV lamps are installed The application of the UV lamps allows the enterprise to decrease load and process requirements for drying in the steam drying chambers and to increase production capacity of the process line

Similar condensate collectors were installed at the UPL Unit, however, they have been dismantled because of problems relating to the maintenance of temperature inside the drying chamber and a high amount of discards The finishing line has not been in operation for the pass few years

It should be noted that in spite of the one-shift operation of all process equipment, steam is supplied to the steam-coils and drying chambers of impregnating and finishing lines 24 hours per day
It is done because it is necessary to blow down the system before starting-up again in order to avoid condensate collection in stagnation zones, which leads to uneven heating of the pressing surface And, in the event the steam supply is shut-down and then switch-on again, additional stresses in the finned pipes take place in the dryers of the impregnation and finishing lines, which results in cracks and pipe rupture This situation is due to the worn state of calorifers

The basic process equipment was put into operation in the period of 1977 - 1987

One of the most expensive energy uses is compressed air Compressed air is used for blowing and cleaning particleboard before pressing and in other process lines The most stringent requirements for compressed air are in the verification (quality control) and grinding line with the most crucial parameter being the low moisture content of air In the near future the Company does not plan to use the equipment for the input verification of particleboard "as received" This is done due to the fact that the quality of PB supplied has been much improved lately

Table 3 2 2 provides a list of the process sections - main consumers of compressed air

Table 3 2 2 Utilization of Production Capacity

№	Process Equipment	Amount, pcs	Air consumption, m^3/min	Pressure, kg f/cm^2
Shop №1				
1	Machine ЦТМФ-1	2	0 074	4
2	Machine ЦТЧФ	1	0 012	4
3	Veneering line МФП-1	2	0 18	5
4	Finishing line DXPJA-475	1	0 18	5
5	Finishing line АКДА	2	0 18	5
Shop №2				
1	Machine СГВП	2	0 083	5
2	Drill ПС-251Э	4	0 1	5
3	Shaped profile board line «Homag»	1	up to15	4-6
4	Veneering and edge process line «Homag»	1	н/д	4-6
5	Veneering and edge process line «Combima»	1	0 63	4-6
6	Profile Milling Machine ВФК-2А	1	0 1	4-6
Shop №3				
1	Impregnating Lines	4	0 01	4-6

Another energy-intensive facility run by the Company are the Dry Kilns in the Lumber Drying Section with two-stack steam dry kilns installed These include eight injection-reversible stationary dry kilns (with the production capacity up 2,200 m^2 per year and internal volume of 29 2 m^3 of standard lumber) and three metal mobile dry-kilns UL-2M (with the production capacity up 3,200 m^3 and internal volume of 29 2 m^3 of standard lumber)

In the central production area of the Company, lumber is used only for the furniture produced under special orders, therefore, the dry-kilns are used for lumber of another factories and outside clients

The drying cycle is 7- 10 days depending on various factors, such as tree species, initial moisture content, etc According to the technological procedure lumber should be dried under stringent temperature and relative humidity parameters in the drying chamber The drying parameters in the dry kiln are regulated by means of valves installed on 2 atm/120^{0}C steam pipes from which steam is supplied into the pre-chamber and moisturizing pipes The steam is injected into the chamber for the purpose of steaming and maintaining required humidity In order to maintain the temperature and humidity throughout the chamber, reverse forced air circulation is provided inside the chamber This is provided in the UPL chamber by six axial reversible ventilators U12 No 12 5 (with the drive capacity of 7 5/8 5 kW) located in the upper part In the injection type chamber this circulation is provided by one ventilator Ts4-70 No 12 (with the drives capacity of 22 kW) located in the end of the chamber opposite to the doors, which supplies air alternatively to nozzles in the left and right parts of the chamber The ventilators operate in an intermittent manner Moist air is sucked from the chamber and fresh air is supplied to the chamber by a combined extract-input ventilation system In spite of the fact that in the initial design all chambers were equipped with automatic control systems, they are not now used This is due to the unreliable operation of the installed control-measuring instrumentation The maximum volume of the steam required to dry 1 m^3 of standard lumber in the injection chamber is 600 kg (for UPL Unit - 590 kg) and electric power - 29 5 kWh (50 8 kWh) The total steam consumption of the dry kilns is 250 kg/hour

4 ENERGY CONSUMPTION PARAMETERS OF THE COMPANY

4 1 Description of equipment and operation parameters of energy systems

Electric Power Supply System

The main production area of the Company is connected to the electric grids by means of two 10 kV inputs at "Chemskaya" and "Olovozavodskaya" substations Feed-lines from the central distribution station (CDS) are connected to the eight transformer substations (*TP*), which supply electric power to the entire main production area and the outside clients A Tapping Switch is installed at the SDC, which makes it possible to use only one input for connecting to the electric grids Parameters of the transformers are provided in Table 4 1 1

Table 4 1 1 Transformers

№	Type	Amount, pcs	Capacity, kWA	Voltage U max\U min, kV	Installation site
Transformer substation № 1					shop №2
1	TM3	1	1000	10/0 4	
2	TM3	1	1000	10/0 4	
Transformer substation № 2					shop №3
3	TM3	1	630	10/0 4	
Transformer substation № 3					shop №1
4	TM3	1	630	10/0 4	
Transformer substation № 4					shop №1
5	TM3	1	630	10/0 4	
Transformer substation № 5					detached
6	TM3	1	630	10/0 4	
7	TM3	1	630	10/0 4	
Transformer substation № 6					detached
8	TM3	1	630	10/0 4	
9	TM3	1	630	10/0 4	
Transformer substation № 7					technical school
10	TM3	1	630	10/0 4	
11	TM3	1	630	10/0 4	
Transformer substation № 8					detached
12	TM	1	400	10/0 4	
13	TM	1	400	10/0 4	

One of the transformers installed in the substations is always in operation with the other one in stand-by, but under voltage
The substations have reactive power compensation units (see table 4 1 2) Reactive power is regulated both in manual and automatic modes

Table 4 1 2 Data on reactive power compensating units

№	Type	Amount, pcs	Capacity, kVAR	Amount of stages	Regulation mode	Location
1	LA-Z-4-IP20-SAH-V2065	3	140	4	automatic	TP-5
2	АКБ-80	3	80	4	automatic	TP-2
3	LA-Z-4-IP20-SAH-V2065	3	140	4	automatic	TP-1
4	AKB-80	2	80	4	manual	TP-3
5	AKB-80	2	80	4	manual	TP-7
6	AKB-80	2	80	4	automatic	TP-6
7	UK-03B-220 NUZ	1	207 5	1	manual	TP-4

TP-1 supplies the entire ventilation system of the workshops of the Factory, the administrative building, shop No 2, impregnation shop No 1, T&C workshop of the tool shop and partially shop No 3
TP-2 covers most of the electric load of lighting equipment of the Factory and T&C workshop of the tool shop and partially shop No 3
TP-3 supplies the Telephone Station, the pressing and cutting workshops (about 2/3 of load), shop No 1 and the administrative buildings
TP-4 supplies the ventilators of the drying chambers, and block-cutting and cutting-to-shape sections of shop No 1 One of the outside clients - the Publisher House, is also connected by a power cable to this substation
TP-5 supplies the boiler station and electric equipment of the warehouse and auxiliary premises of the Factory (crane KGS-10, warehouse for plates, resins and lumber) One of the outside clients - Garage Cooperative "Mebelshik" is also connected to this substation
TP-6 supplies the compressor station, the fire-fighting brigade, two garages of the Factory, the secondary pump station for city-water supply system, laundry, green-house (not in operation), sewage pump station and outside clients garages "Sovetskaya Sibir", Cooperative "Cultura" and the gasoline station "Nord"
TP-7 supplies the binding process lines and outside clients, including canteen, technical school and street lighting system in the area adjoining the Factory
TP-8 supplies only outside clients, including small business "M-1989 and the city street lighting system

Meters are installed at the distribution substation "Chemskaya" and "Olovozavodskaya" for commercial accounting of active and reactive power consumption All settlements with the outside clients are made on the basis of reading the meters For internal accounting at the CDS meters are installed at each power distribution cubical These meters were earlier used in the automatic electric power metering system Ts-500, which provided data transmission from each meter to the central computer Presently this system is not operating although management is considering its possible repair

Lighting System

Different types of lamps illuminate the workshops of the Company Table 4 1 3 provides data on the lighting equipment installed at the Company

Table 4 1 3 Installed lighting load of workshops of the Factory

№	Lamp type	Location	Amount, pcs	Installed capacity, kW
Shop №1				
1	ПВЛМ 2×80	*Shop* 1	404	64 6
2	СКЗПР-400	press and block sectors	31	12 4
3	filament lamp (60 W)	*Shop* 1	15	0 9
4	ПВЛМ 2×40	*Shop* 2	22	1 8
Shop №2				
5	ПВЛМ 2×40	*Shop* 2	406	36 4
6	ПВЛМ 2×40	consumers goods and gage sections	104	11 3
7	ПВЛМ 2×40	grinding room	60	4 8
8	filament lamp (60 W)		20	1 2
Shop №3				
9	СЗПР-ВЗГ (ДРЛ-125)	varnishing section	135	16 9
10	СЗПР-ВЗГ (ДРЛ-250)	varnishing section	220	55
Industrial area lighting				
11	КПН 1000	lighting poles	7	7
12	СКЗПР-400	area of the Factory	16	6 4
13	СКЗПР-250	area of the Factory	112	28
	TOTAL			246 7

Air Supply System

The Air Supply System is a centralized type There is a detached compressor station building Table 4 1 4 provides a list of air compressors installed

Table 4 1 4 Air Compressors

№	Compressor type	Put into operation in	Amount pcs	Capacity m^3/min	Pressure kg f/cm^2	Drives capacity, kW	Cooling system	Cooling water flow rate, m^3/h
1	6ВВ-25/9	1986	1	25	8	200	air	--
2	6ВВ-25/9	1986	1	25	8	200	air	--
3	6ВВ-25/9	1986	1	25	8	200	air	--
4	ВП-20/8М	1975	1	20	8	125	circulating	2 5

The pressure of 5-7 atm is maintained in the air lines In the event that air pressure in the lines exceeds 7 5 atm, the screw compressors are automatically switched to idle and their electric power consumption slightly drops If the piston type compressor is operating no capacity regulation is available, and in the event of excessive pressure in the lines a relief valve is activated and the compressed air is discharged into atmosphere Only one piston compressor was in operation during the energy audit The piston compressor is being used instead of screw compressors because during the summer season the screw compressors are often overheated at high ambient temperatures Oil overheating is caused by the insufficient capacity of the oil cooler installed outdoors as well as the lack of summer types of oil In the winter, air is compressed by screw compressors

Presently the compressor operates only during the work shift It is switched-off at night

Four 7 m^3 receivers are installed at the output of the compressor station with two of them pressurized when one compressor is operating A KSD-2 Compressed Air Meter is installed in the compressor station This Meter is defective and needs repair The two-stage VP piston compressor has a water cooling system An after-cooler is installed after the compressors at the common compressed air collector After this after-cooler air goes to the drying chambers At the moment of the energy audit the drying system was not operating After intermediary and after-coolers, the water was discharged to the sewer because the return pipe of the cooling system was damaged

Ventilation System

Since processes involved in furniture production impose special requirements for ventilation, the Factory is equipped with powerful extract-input ventilation and exhaust systems The workshops are equipped both with general-exchange ventilation and individual ventilation systems installed at the main production equipment The basic ventilation equipment is aggregated at a ventilation rack, which accommodates air ducts to various workshops and process section of the Factory The aggregate capacity of the ventilators installed at the rack amounts to 860 kW During the energy audit 5 ventilators with the drive capacity of 37 kW each were operating There are 90 ventilators in the extract ventilation system at various facilities of the Factory Ventilation is switched-on in the beginning of the shift and switched-off in the end Presently, when the process equipment is not used at its full capacity, they use distributed extract ventilation systems with powerful ventilators for the operation of small process units

A waste transport pipe along the ventilation rack to the boiler station transports sawdust collected in hoppers Currently, this waste transport system is not operating because the grinding-verification machines are not often used, so no sawdust is generated

Heating System

Heating energy for process purposes, heating, ventilation and hot water supply (HWS) is generated by the Factory's boiler station, which completely covers the Factory's needs In addition, heating is supplied to outside clients

Steam for process purposes is supplied from a pipeline to Furniture Factory No 2 incorporated into the Company and located 650 meters from the main area and to the Auxiliary Production Company (*KPP*) Hot water for heating is supplied to a number of enterprises, including Furniture Factory No 2, small business "MP-1989" and cooperative garages where a water meter and heat-meter are installed for measuring the amount of supplied heat The settlement for supplied heat is carried out on contractual basis

The heating system is a double-pipe with dependent connection to the clients After reconstruction, the delivery water pipeline system was changed from crawlway pre-cast concrete ducts to an overhead pipeline, which facilitates the detection of damage to the pipes and their repair The insulation of outside pipes is satisfactory The type of the heating pipeline to Furniture Factory No 2 has also been changed to the overhead system recently

Boiler Station

The Boiler Station was put into operation in 1974 One water heating boiler KV-TS-20 had been in operation, and four additional steam boilers were later put into operation, including two DKVR-20-13, KE-25/14 and KE-6 5-14 All boilers had been using coal before 1984 After their revamp with the installation of slot burners along the perimeter of the boilers natural gas was introduced, and currently coal is used as stand by fuel Boiler No 1 (KE-25/14) was revamped in 1997 with the installation of injection burners BIG and steam-superheaters The installation of the burners of this type was strongly recommended by the State Gas Inspection Authorities of the Ministry of Gas Industry Steam is overheated to a temperature of 225^{0}C Three-day test runs of the boiler proved the possibility of generating steam of design parameters In 1998 the boiler should pass official certification with the State Gas and Technical Inspection Authorities of the Ministry of Gas Industry

Specialist of the *TsKTI Polzunov* R&D Institute revamped KE-6 5-14 boiler for combined and separate incineration of wood waste, gas or fuel oil Coal is the stand by fuel The main source of sawdust was the particleboard grinding line containing toxic phenol-formaldehyde resins When the boiler is burning sawdust, gas and fuel oil is used mostly for auxiliary purposes Presently, since the quality of particleboard supplied to the Company has improved, the grinding line is operating in an irregular manner and the amount of toxic dust is negligible, so KE-6 5-14 boiler is used very little The boiler may be used in a rated mode using natural gas only in case additional gas burners are installed

The boilers are equipped with automatic systems maintaining gas-air ratio in accordance with a process chart for the boiler and specified pressure of steam supplied to the clients These steam boilers feature an air heater, which increases their operation efficiency

Table 4 1 5 includes performance parameters of the boiler installed at the Company In the boiler room, there are two module-type delivery water heating units and two hot water supply boilers, water chemical treatment units, sodium cycle, two deaerators for make-up and feed delivery water of the heating system, steam heater for fresh water, water-water heater of deionized water, salt-diluter and chemical agent facilities for "wet salt storage" The boiler room also accommodates delivery and feed water pumps, recycling water pumps of the hot water supply, treated water pumps to feed the deaerators and salt pumps The characteristics of auxiliary equipment are provided in Table 4 1 6, and parameters of the pumps - in table 4 1 7

In accordance with the principle process-flow diagram of the boiler, input water from the water supply system is first heated in the steam heater to a temperature of 25-30^{0}C with direct steam It then goes to the filter of the first and second stage filters of the Chemical Water Treatment facilities, and then treated water goes through the water heat-exchanger, where hot water from continuous blowdown separators is used as the heating medium, it then goes to the deaerator, and then passes through a vented steam-cooler installed on the deaerator near its head

Steam generated by the boilers goes to a steam-distributing box bypassing the reducing chamber and then goes to the users It is used for the processing needs of the Factory, the needs of the boiler station, the boilers of the heating system and hot water supply and to the outside clients (Factory No 2 and Auxiliary Production Company [*KPP*])

All steam boilers feature periodical (30 sec) and continuous blow-down (with the exception of boiler KE-6 5-14MT)
Air suction for the burners in the boiler house comes from the premises and outdoors A gate valve regulates air intake from the boiler premises As a rule, outdoor air intake is used in order to avoid cold air-inflow to the boiler house

Chemical Water Treatment Facilities

Treated water is supplied to the feed water deaerator after the second stage of the Chemical Water Treatment Unit (CWU) Treated water is supplied to the make-up water deaerator after the first stage of CWU

There are seven water filters installed in the boiler house They operate according to a two-stage affluent water-treating scheme, which includes four filters of the first stage and three filters of the second stage Presently, they have started using KU-1 cation-exchange resin capable of operating at water temperature up to 85^{0}C instead of sulfonated coal Sulfonated coal is used in the second filtering stage Tap water supplied to the boiler house has the total hardness of 1,500-8,000 mkg equ /l (which is much higher in the winter season) The hardness of chemically treated water after the first stage does not exceed 100 mkg equ /l and after the second stage - 15 mkg equ /l When the hardness of treated water exceeds 100 mkg equ /l filters of the first stage are disconnected for regeneration The first stage filters are regenerated 2 times per day in the winter and 1 0-0 5 times in the summer The second stage filters are regenerated once per month The quality of treated water after the first stage filters allows it to be used as make-up water for the heating system

The measurement of natural gas consumption by the Furniture Factory and settlements with the city's gas suppliers are carried out in accordance with readings of the gas meter

Table 4 1 5 Boilers

№	Boiler type	Amount pcs	Capacity, t/h	Pressure oper /actual kg f/cm^2	Efficiency «Gross»	Hours in operation per year	Annual fuel consumption thsnd stndrd tons	Annual heat supply, GCal	Put into operation in	Remarks
1 Steam Boilers										
1	ДКВР-20/13	2	20	13/11	92 7	8760	8,840	57,363	1976	№2, 3
3	КЕ-25-14С	1	25	13/11	--	72	н/д	н/д	1979	stand by
4	КЕ-6 5-14МТ	1	6 5	13/11	84 3	--	--	--	1994	
2 Water heating Boilers										
5	КВТС-20	1	20	16/10	91 07	5448	3,120	19,890	1977	

Table 4 1 6 Auxiliary equipment of the Boiler House

№	Equipment	Units	Boiler №1	Boiler №2	Boiler №3	Boiler №4	Boiler №5
1	*Economizer*		*ЭП-1-646*	*ВТИ*	*ВТИ*	*none*	*7Б2-142Н*
	heating surface	m^2	646	646 6	646 6	--	141 6
2	*Blow fan*		*ВДН-12 5*	*ВДН-10*	*ВДН-10*	*ВДН-13 5*	*ВДН-9*
	capacity	nm^3/hour	26,600	23,500	23,500	43,150	10,200
	head	mm water column	243	138	138	105	219
	r p m	min^{1}	1,000	730	730	585	975
	motor capacity	kW	30	22	22	40	11
3	*Smoke Extractor*		*Д-13 5*	*Д-13 5*	*Д-13 5*	*Д-18*	*ДП-12 5*
	capacity	nm^3/hour	45,000	45,000	45,000	74,550	35,000
	head	mm water column	175	175	175	320	245
	r p m	min^{1}	735	735	735	585	975
	motor capacity	kW	55	55	55	50	34

Table 4 1 7 Pumping Equipment

№	Item	Type	Amount, pcs	Capacity, m^3/h	Head, m	R P M	Drives capacity kW	Hours in operation per year
1 Heat supply pumps installed in the boiler house								
	feed	ЦНСГ 38/220	2	38	220	3000	45	8760
	network	ЦН-400/105	2	400	105	3000	200	5420
	feed	н/д	1	н/д	н/д	н/д	160	--
	make-up	К20/30	2	20	30	3000	4	5420
	circulating	НКУ 140/40	2	140	40	1500	40	8760
	Hot water supply	КМ45/30	2	45	30	3000	15	8760
2 Pumps of the water supply system								
	cold water	Д 320	4	320	50	1500	75	8760
	sewage	СД 160	2	160	10	960	7 5	4380
3 Recycling cooling water for compressors								
	to the Cooling Tower	К-90/30	2	90	30	3000	18	--
	to compressors	К-90/30	2	90	30	3000	18	--

Heating and Ventilation Systems

Water is used as heat-carrier for the heating system and input ventilation Water heating boiler KVTS-20 with a capacity of 20 GCal/hour, a section of water heaters MVN 1437-06 with the heating surface of 62 3 m^2 and two water-water heaters (condensate coolers), type MVN-2052-34 with the heating surface of 42 m^2 installed in the boiler house are used for this purpose Two delivery water pumps are continuously operating in order to supply water to the heating system, the parameters of these pumps and a stand-by pump are provided in Table 4 1 5

The local heating system is a double-pipe type with a dead-end flow-scheme and elevating connections to the users There are 20 users' connections

The heat consuming equipment includes calorifers, input ventilation systems, convection-radiation heating devices, smooth and finned pipe combs, converters and heating radiators Most production buildings are heated by calorifers of the input ventilation systems or by the same calorifers in combination with convection-radiation type heating devices Water to the calorifers of the input ventilation system is supplied from the heating loop

There are 9 heat screen blowers installed at the Factory with delivery water used as heat-carrier in these calorifers

Hot Water Supply (HWS)

Water for the hot water supply is heated by two HWS Boilers located in the boiler house Hot water is supplied according to a circulation scheme Unused hot water returns to the boiler house, where it is mixed with cold water and sent to the boiler again Circulating pumps provides water circulation
Return water in the boiler is heated by steam-condensate blend from the process equipment After the heat exchanger, the condensate is sent to the deaerator

Hot water temperature maintenance is carried out manually by the operator No automatic hot water temperature control system is available There are no surge drums in the hot water supply system

Water Supply

Water intake from the city water supply for use in the Factory is carried in the following manner Water from the city water supply pipeline is supplied to two interconnected reservoirs with a volume of 1000 m^3 each From these reservoirs, water is pumped by one of the fours available pumps, type D-320, which provide the required head for the water supply system of the Factory The pump operates continuously No start-up and capacity regulating automatic system is available Rated water flow is 320 m^3/hour, head - 50 m with the drives capacity of 75 kW All settlements with the water supply Company are made based on the readings of the KSD-2 commercial water meter installed on the water intake line from the city water supply before the surge reservoirs

Sewage is channeled into tanks and is then pumped to the city sewerage by pumps with a drive capacity of 7 5 kW The sewage pump operates in a periodic manner The pump is started when a pre-determined level is reached in the sewage tanks A sewage flow meter is installed on the sewage discharge line and all payments for sewage disposal services are made in accordance with the reading of this meter

4 2 Energy consumption and costs analysis

The Furniture Factory "Novosibirskmebel" consumes gas, electric power and water Table 4 2 1 provides data on the fluctuation of utilities consumed by the Factory in 1994-1997

Table 4 2 1 Utilities consumption in 1994-1997

Utility	Units	1994	1995	1996	1997
Gas	thousand m^3	14,009	13,645	13,786	10,404
Electric power	MWh	11,639	11,707	8,740	6,270
City water	thousand m^3	610	520	560	669

A 46% drop of power consumption and 26% drop of gas consumption took place in 1997 with a substantial production drop (60-65% as compared with 1994) Water consumption increased almost 10% at the same period

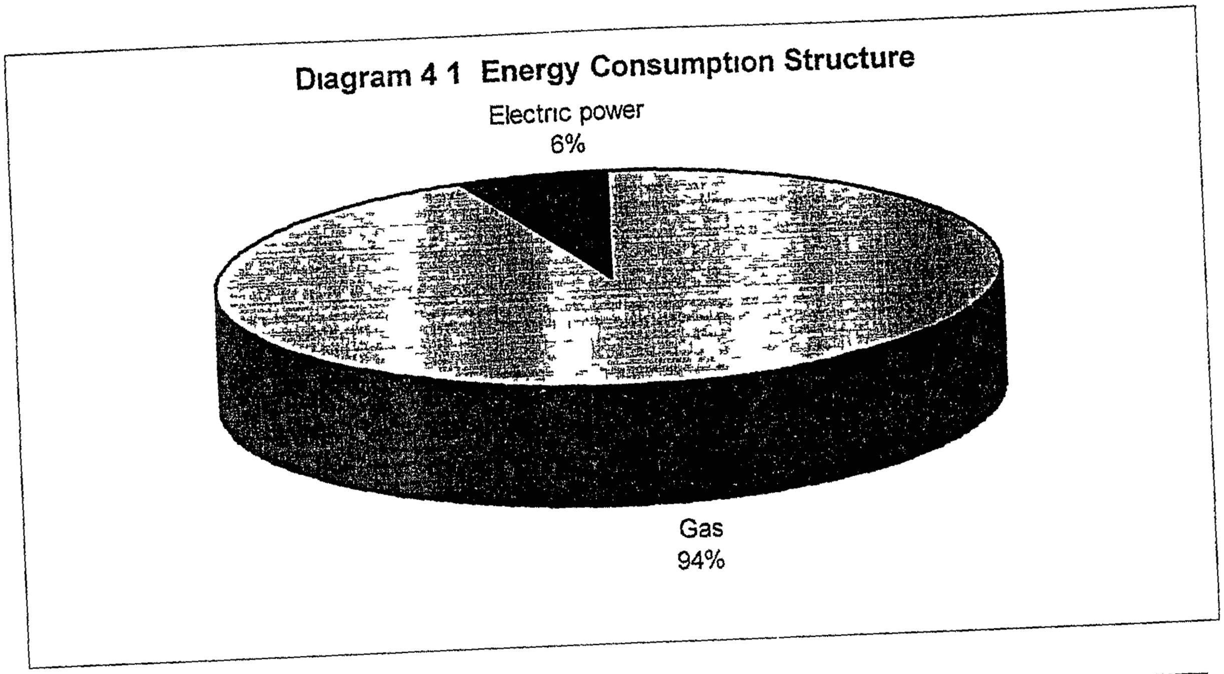
Table in Appendix II provides data on the monthly utilities consumption of the Factory workshops in 1997

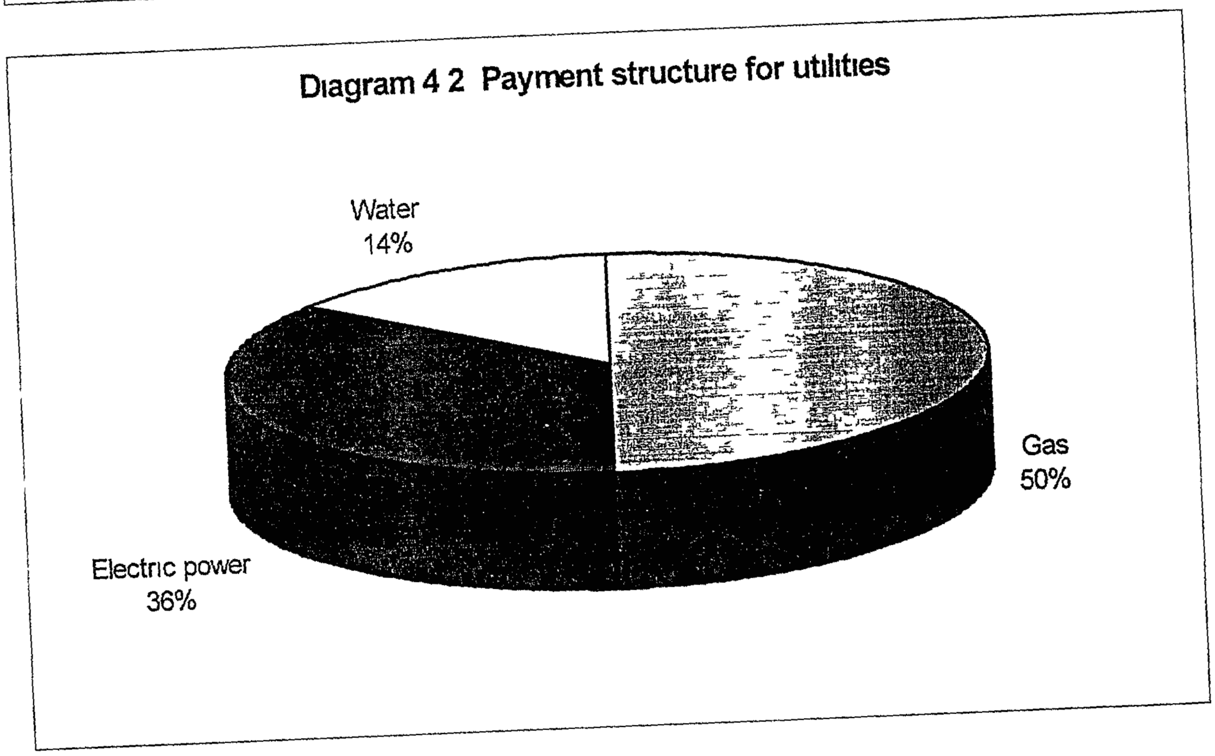
Table 4 2 2 provides data on the total consumption of various types of utilities in terms of standard equivalent units in 1997

Table 4 2 2 Payments and Consumption of Utilities in 1997

Utility	Unit	Consumption	Energy		Price	
			GJ	%	thousand rubles	%
Gas	thousand m^3	10,404 4	353,957	94	3,056 9	49 9
Electric power	MWh	6270	22,572	6	2,200 1	35 9
City water	thousand m^3	669	--	--	872 7	14 2
Total			**376,529**	**100**	**6,129 7**	**100**

Diagrams 4 1 and 4 2 below shows the utility structure calculated in terms of energy equivalent and the structure of payments for utilities used in the main production area of the Factory

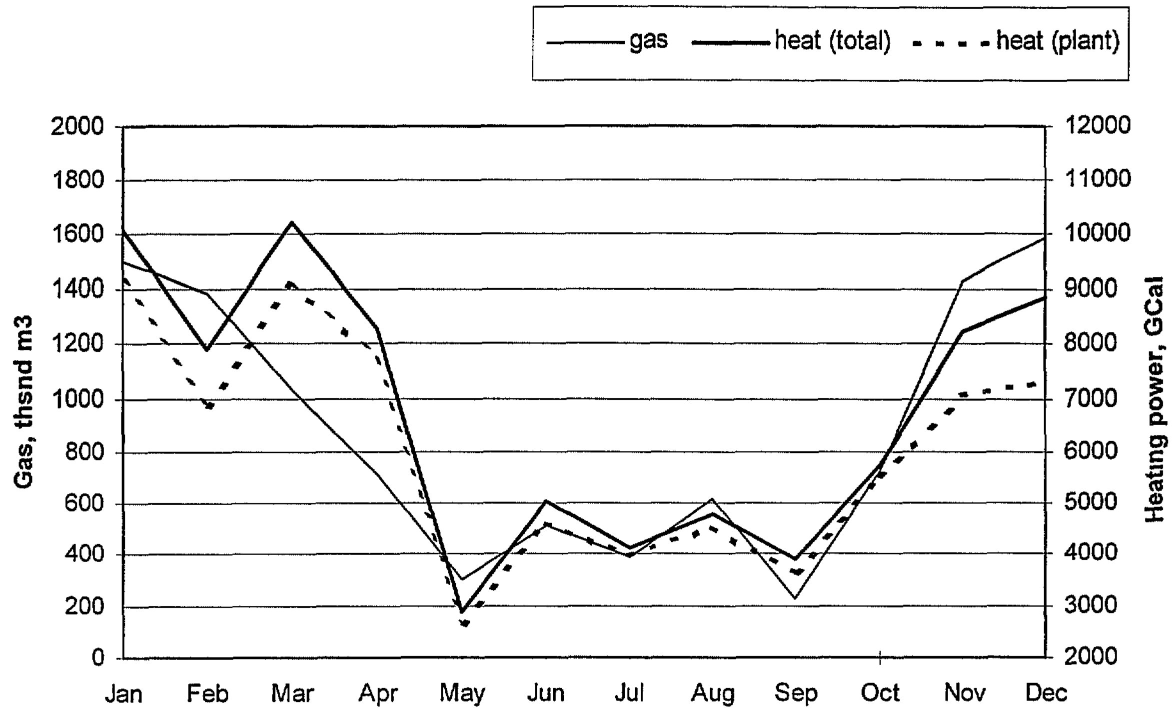




According to the above diagram about 50% of the utility payments is for the cost gas Therefore, most attention in the development of energy efficiency programs should be paid to the heating and steam supply systems

Fig 4 2 1 shows monthly gas consumption and heating energy generation dynamics The dotted line corresponds to the heating energy consumed directly by the Factory

Fig 4 2 1 Gas consumption in 1997 r and heating energy generated by the boiler house

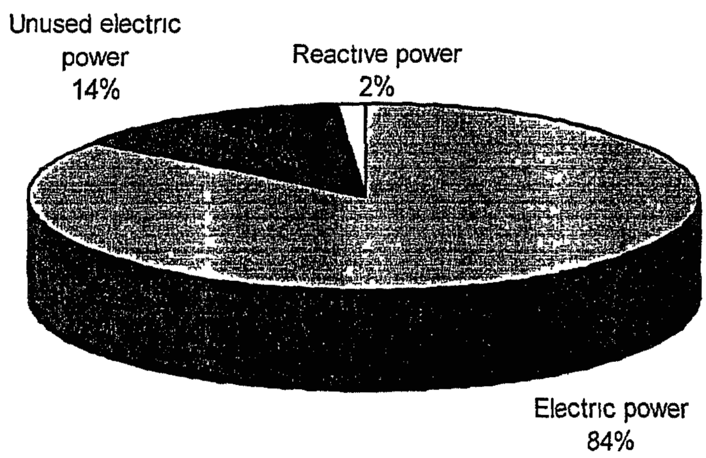


About 10% of the generated steam is supplied to outside clients

About 36% of all energy payments are for electric power The Factory pays its electricity bills on a contractual basis under the "One-Rate Tariff" Additionally it pays every three month (quarter) the outstanding amount of electric power under the power supply contract it failed to use in full The Factory pays for the actually consumed reactive power in the same manner

Diagram 4 3 shows the structure of payments for electric power

Diagram 4 3 Electric Power Payments Structure

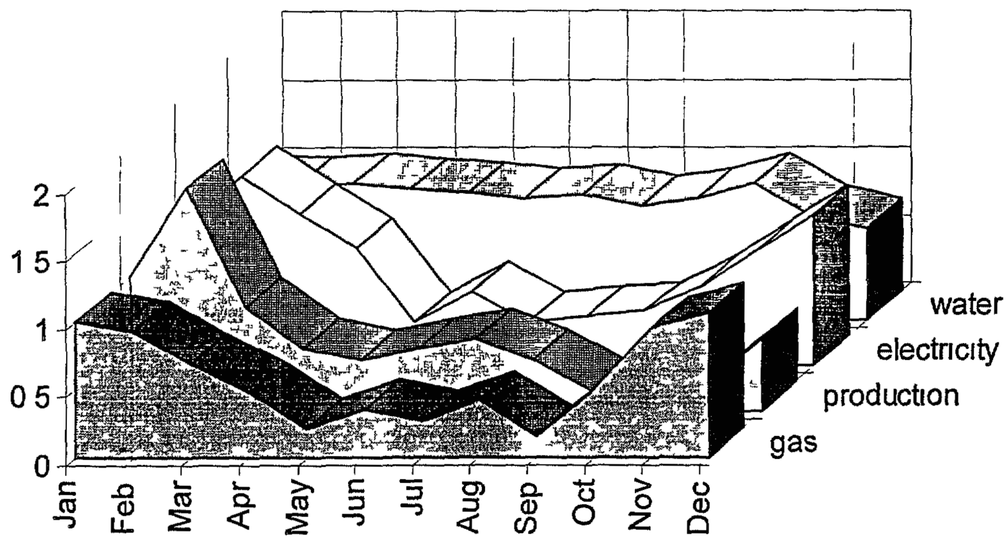


The main electric energy consuming equipment is ventilation and processing equipment

About 14% of all energy payments is for the water supply Taking into account the fact that with current production drop water consumption increased almost by 10% (as compared with 1994) The payment amount for water seems to be too high

The correlation between utility consumption and production volume in 1997 is shown in Diagram 4 2 2 Utilities consumption and production output are provided in assumed standard units as compared to January 1997

Fig 4 2 2 Dependence of energy consumption on production output



The production curve reflects the variance of basic furniture output, furniture sets and antechamber furniture It should be noted that the unbalance of monthly power consumption and production peaks may be explained in the following manner output production reporting is always made based on the in-warehouse amount of furniture, whereas in practice there usually are nearly finished pieces of furniture for the production of which a large amount of energy resources has been spent Such pieces are not included into the output production report only because one minor technological operation has not yet been completed, for example, because of the lack of components, consumable materials or parts

According to the diagram, the gas and power consumption curves feature seasonal fluctuations and mostly follow monthly production output variations, whereas the water consumption curve is practically flat Some water consumption drop at the end of the year is connected with the repair work done to eliminate leaks in heating and cold water pipelines

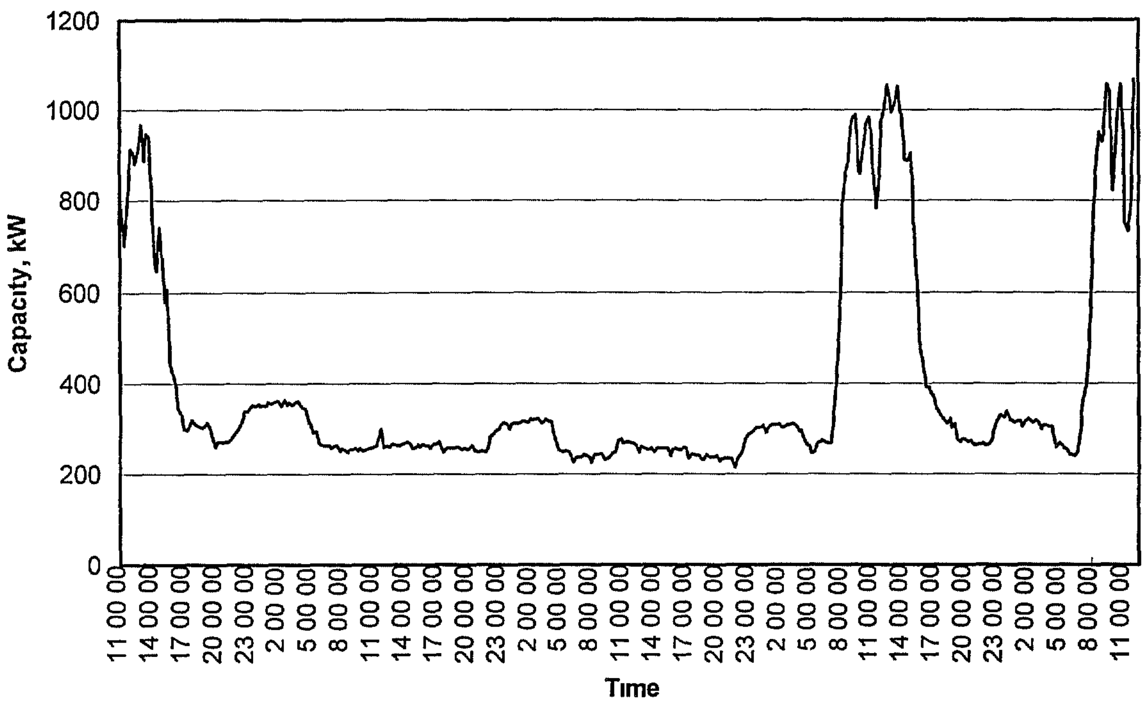
5 ENERGY EFFICIENCY MEASURES

5 1 Results of measurements made at the Factory

Elite 4 Loggers and a Fluke Multi-Meter were used for the purpose of this energy audit The Logger was installed on the commercial electric power meter in order to check the amount of electric power consumed by the Factory Regular data collection from operational electric power meters located in the Central Distributing Room and electric power meters measuring power supplied to outside clients was implemented An Elite 4 was installed on the pump for the second City Water lift in order to define its energy efficiency and load factor This pump was selected because it is large, quite powerful and operates continuously 24 hours per day The resulting curves are provided in Appendix IV

Fig 5 1 1 demonstrates the dependence of the total power consumption by the Factory in the period of July 3 - 7, 1998 taking into consideration outside client's consumption (a daily power consumption curve including outside clients is provided in Appendix IV)

Fig 5 1 1 Aggregate energy consumption curve for the period from 03 07 until 07 07 98



The night load peaks (about 70 kW) are general caused by lighting system consumption by the outside clients, including city street lamps According to the meter readings, the night lighting load of the outside clients is about 110 kW Considering the Factory operates one shift and the amount of justified night load is much lower then one which was actually registered (the boiler house, water supply and sewage pumps, the lighting system of the production site and dry kilns are operating during the night) it seems that about 80 kW corresponds to the consumption of electric devices left energized for the night At the same time we carried out one-time measurements of consumed capacity for most of the electric power devices with the aim of developing an energy balance of the Factory (see Table 5 1 1) All measurements were made during the day from 11 a m until 2 p m The measured consumed capacity of the administration building includes electric lighting loads as well as electric power consumption by air conditioners (about 30 air conditioners, 1 2 kW each) and domestic heaters

Table 5 1 2 Consumed power measurement data for individual equipment on 3-4 July

№	Equipment	Installed capacity kW	Consumed capacity, kW				cos φ	Loading factor, Кз
			F №1	F №2	F №3	sum		
TP-1								
1	Administrative building (lighting system)	--	21 8	27 5	32 8	82 1	0 9	--
2	Administrative building (power)	--	1 8	2 8	3 5	8 1	0 87	--
3	Domestic premises	--	1 0	0 9	0 8	2 7	0 83	--
4	Ventilation (MKSh section)	--	14 0	14 7	15 2	43 9	0 65	--
5	Ventilation duct rack	--	19 6	19 0	19 0	57 6	0 83	--
Boiler house								
1	Lighting	--	2 1	1 7	1 6	5 4	0 9	--
2	Blow fan №4	40	1 9	1 6	1 6	5 1	0 43	0 13
3	Smoke Extractor №4	50	4 2	3 6	3 9	11 7	0 52	0 23
4	Hot water pump	15	2 7	2 8	2 8	8 3	0 8	0 55
5	Feed pump	45	8 2	7 9	8 0	24 1	0 78	0 54
TP-5								
1	Repair Shop	--	1 8	2 7	2 2	6 7	0 76	--
2	New garage	--	0 5	4 4	0 5	4 5	0 77	--
3	Fire-fighting brigade	--	1 2	0 5	3 0	4 7	0 9	--
TP-4								
1	Wood Block Workshop	--	2 8	2 7	2 7	8 2	0 5	--
2	Lighting and Ventilation System of Shop №1	--	1 2	0 9	0 1	2 2	0 52	--
TP-7								
1	Canteen (time 14^{10})	--	4 2	4 4	1 0	9 6	0 96	--
TP-2								
1	Finishing line, shop №3	--	11 6	11 1	11 7	34 4	0 87	--
2	Lighting system, shops 2 and 3	--	2	1 7	2 7	6 4	0 83	--

At the time of the measurements most of the process equipment was idle

According to the results of measurements the electric power consumption balance for the Factory was made (see Table 5 1 2) It should be noted that all measurements were taken after the heating season ended, so the load for input ventilation and pumps of the heating system was equal to zero

Table 5 1 2 Electric power balance of the Factory

№	Consumer	Power consumption, %
1	**Lighting system**	15 7
2	**Boiler house**	15 9
3	**Water supply**	7 9
4	**Technology**	14 8
5	**Ventilation system**	8 0
6	**Air supply**	7 9
7	**Outside clients**	19 2
8	**Conditioners АБК**	2 4
9	**Others**	8 2
	TOTAL	**100**

The above measurements demonstrate that a large part of electric power consumption corresponds to lighting and ventilation systems Consumption by the ventilation system is higher, which may be explained by the fact that the ventilation system is not divided into separate independent sections for each process line and workshop

Compressed Air Supply

For the purpose of this audit a test was made with the objective of evaluating air leakage in the compressed air system The test was carried out in the following manner After the end of the work shift, when all end-users were not operating, pressure in the system was maintained at the level of 6 8 atm The pressure dropped within a test period of time and then a piston compressor was started and the rated pressure was restored The leakage volume during the test time plus time of pump operation was defined by the time of pump operation The compressed air system was also examined as a whole during the test

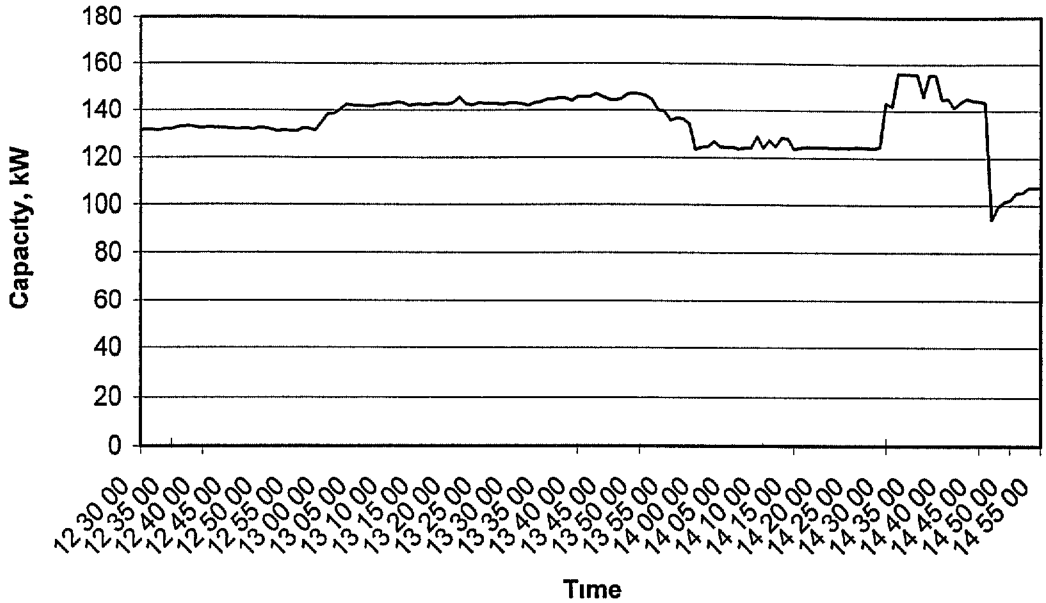
Date 0 7 07 1998
Time 16 30

№	System section	Test time	Pressure drop in the system	Compressor operation time	Leakage volume	
		min	atm	min	m^3	%*
1	All system	7'20''	2 3	7'40''	10 3	51 5

* - Percentage of leakage volume was defined as follows ratio of leakage, m^3 (10 3) to the total air consumption during the test time (15 minutes) at the rated compressor capacity equal to 20 m^3/min

Air leaks in valves of the end-users were found during the visual inspection of the compressed air system The repair of the system could be effective only in the event that a compressor with automatic capacity adjustment is used A screw compressor with an automatic capacity adjustment system and automatic switching to the idle mode was started for the period of 2 5 hours for the purpose of a test The test compared consumption parameters of the piston compressor (with the capacity of 20 m^3/hour) and the screw compressor (with the capacity of 25 m^3/hour) during the work shift Figure 5 1 2 illustrates the electric power consumption curve of the screw compressor

Fig 5 1 2 Electric power consumption by the screw compressor, 23 July 1998 r



Before switching to the screw compressor an instantaneous measurement of consumed capacity of the piston compressor was done, which amounted to 115 kW A daily electric consumption curve for the piston compressor is provided in Appendix IV The average consumed power of the screw compressor during 2 5 hours was 135 kW It should be noted that in the event all leaks are eliminated, it would be possible to decrease the consumed power of the screw compressor Thus, from the point of view of electric power consumption, the use of a powerful screw compressor instead of the piston compressor is not practical at this time

A number of measurements were made with the objective of evaluating the performance of the air coolers (intermediary and end ones) of the piston compressor

Water flow rate	Through intermediary cooler	- 2 5 m^3/hour
	Through the end-cooler	- 2 6 m^3/hour
Water temperature	After the I stage	- 140°C
	After intermediary cooler	- 55°C
Water temperature	Before intermediary cooler	- 22°C
	After intermediary cooler	- 36°C
Air temperature	After compressor	- 115°C
	After end-cooler	- 31°C
Water temperature	Before intermediary cooler	- 22°C
	After intermediary cooler	- 36°C
Cooling water pressure		- 3 8 atm

Considering the comparison of the two compressors types, it should be noted that in spite of water savings in the amount of 2 5 m^3/hour (for the screw compressor), which amounts to about 5 13 rubles in current water prices, a 20 kWh overrun of electric energy is equal to 5 8 rubles Therefore, under the current operation mode of the Factory it is more feasible to use the piston compressor

Dry Kilns

According to information provided by operators of the Dry Kiln Section the drying periods substantially differ for various drying chambers One of the reasons for the drying time increase is a drop of air circulation in the drying chamber Since the circulation rate in the chamber is connected with the rotation speed of the ventilator fans, it was decided to measure the r p m parameters of the ventilators in the injection chambers by measuring the consumed power of the ventilators The ventilators are driven by a four-stage belt transmission The results of the measurements are provided in Table 5 1 4 where actual and rated r p m parameters are compared The parameters of air consumption and rotation speed of the ventilators are provided in accordance with the technical specifications (certificate) of the dry kilns

Table 5 1 4 Rotation speed and consumed power variances of injection-reversible drying chambers

Dry Kiln №	Ventilator type	Air flow rate, m^3/hour	Rotation speed, min^{-1}		Capacity, kW		cos φ
			passport	act	drive	cons	
1	Ц 4-70 №12	46,000-50,000	818	524	22	14 5	0 85
2	Ц 4-70 №12	46,000-50,000	818	630	22	17 3	0 79
3	Ц 4-70 №12	46,000-50,000	818	494	22	4 7	0 53
8	Ц 4-70 №12	46,000-50,000	818	657	17	9 5	0 73
9	Ц 4-70 №12	46,000-50,000	818	621	17	10 7	0 81
10	Ц 4-70 №12	46,000-50,000	818	637	22	8 2	0 54
11	Ц 4-70 №12	46,000-50,000	818	700	22	12 1	0 69

According to the above Table the rotation speed of many ventilators is much lower than the rated parameters The speed may be increased by means of installing missing drive-belts and replacing worn and torn ones In the present situation the lower rotation speed of the ventilators may lead to a substantial increase in drying time It is difficult to make quantitative evaluation of the dependence of the drying time to the decrease of circulating airflow rate Such evaluation required additional tests

Boiler House

The Boiler House is the only user of natural gas at the Factory In the course of the energy audit the temperature and composition of gas incineration products were measured after boiler No 3 and before the economizer and smoke extractor A BACHARAH Gas Analyzer was used to take the measurements A US flow meter made by *Panametrics,* was used to measure the chemically treated water flow rate to the deaerator, and the flow rate of the direct and return water in the hot water supply system An *IR Ranger* (infrared thermometer) was used to measure surface temperatures of various elements of the boiler, air ducts and pipelines, including steam pipelines A measuring flask was used to measure secondary evaporation condensate consumption in a continuous-blowing steam separator The results of tests and heat loss calculations for the boiler are provided in Appendix IX

The following could be noted basing on the results of measurements

- Gas-air ratio in the burners is maintained automatically in accordance with the given operation parameters and operation chart of the boiler, which ensure as a whole, efficient gas incineration (first CO traces detection in effluent gases),

- Air suction throughout the boiler to the economizer is equal to 67% with 95% after the economizer, which results in 8 7% of fuel lost with effluent gases The results of air suction measurements are approximately equal to those specified in the operation chart of the boiler, however, the reduction of these losses to rated values would allow a saving of 2-3% of the fuel,

- A 10 MPa (1 mm water column) reduction of vacuum in the boiler furnace would allow a reduction of air suction by 24% and to increase the boiler efficiency by 1 3% correspondingly,

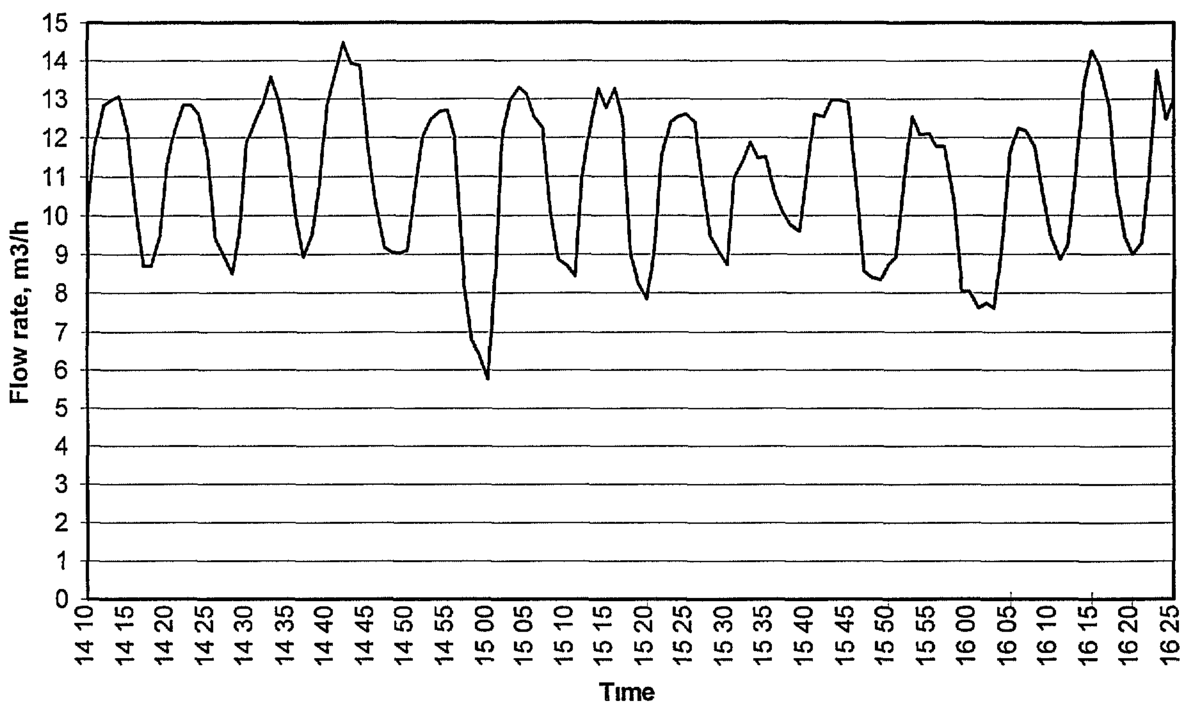
- The measured blowdown volume was equal to 950 kg/hour, which is about 10% of boiler capacity During blowing 120 kg of secondary evaporation steam is generated, which is sent to the deaerator, and 730 kg of condensate, which is sent to the heat exchanger for chemically treated water After the heat exchanger, the condensate is discharged into sewerage,

- The air temperature after the heaters was equal to 140^{0}C,

- During the visual inspection of the heating pipeline system in the boiler house it was found that all pipes of the hot water supply system, delivery water system and condensate return had no thermal insulation The insulation was partially lacking on pipelines, a boiler of the heating system and input steam pipeline (see Appendix VIII)

During the measurements made on July 20-29 the following situation was observed the deaerator was operating using only the direct steam, due to the fact that the amount of heat of the returned steam-condensate blend was not sufficient for the normal operation of the deaerator, and its additional heating was difficult because of the excessive pressure of this blend Therefore, only a small part of returned heat was used to heat the hot water Measurements of the flow rate of the chemically treated water (see Fig 5 1 3) carried out with the aim of evaluating the share of condensate returned to the boiler house from the process units proved the above consideration, i e treated water consumption is practically equal to the amount of produced steam - 11 ton/hour allowing for continuos blowdown A discharge pipe from which steam from the return steam-condensate pipeline is discharged into the atmosphere was inspected during the shutdown of the boiler house with the objective of explaining the cause of such large losses of the steam-condensate blend According to the results of the visual inspection it was found that a 25-mm nozzle reducing steam losses at the end of 159-mm pipe was missing If the nozzle is installed it will reduce pass-steam and steam-condensate secondary evaporation losses and stop the supply of live steam to the deaerator, thus saving a lot of heat energy The system should be restored before the beginning of the heating season

Fig 5 1 3 Consumption of Treated Water



The average flow rate of the treated water was 11 7 m3/hour, which was practically equal to the flow rate of feed-water to the boiler, i e a complete loss of condensate takes place

Heating System

The heating system was disconnected during the measurements because it was the end of the heating season A visual inspection and discussions with the boiler personnel and data from a heat delivery journal, where appropriate parameters of delivery water, allowed us to make the following conclusions

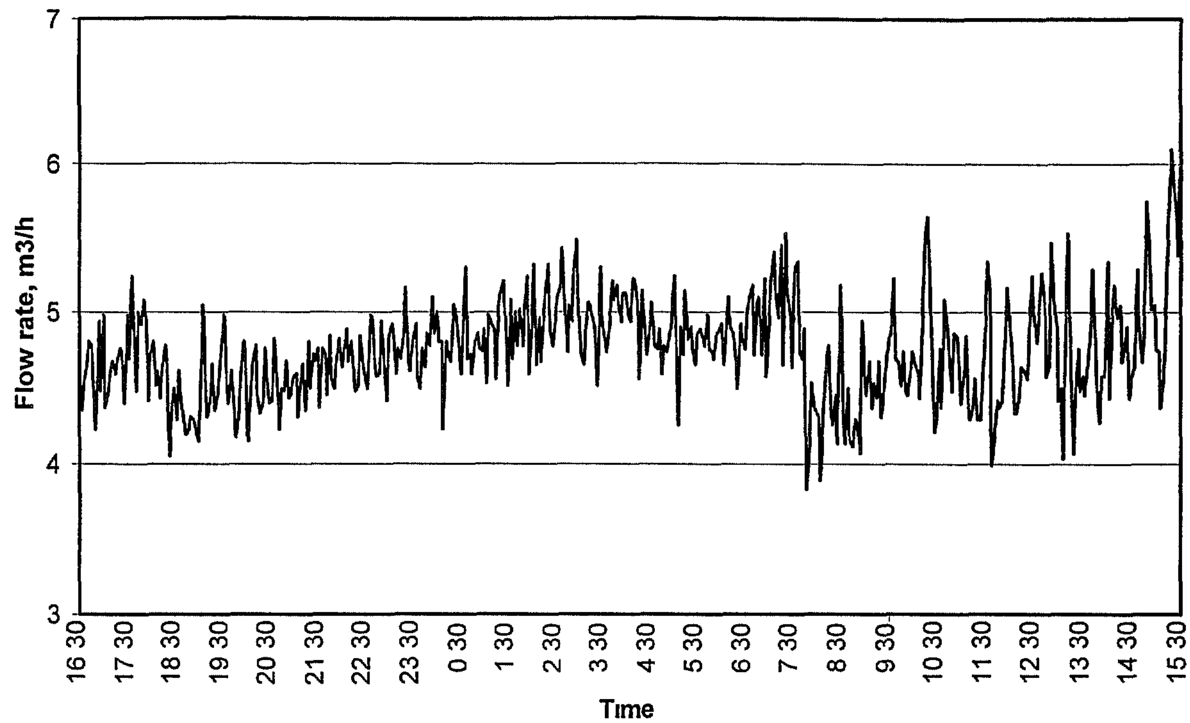
* There is no automatic temperature control system for the direct delivery water supply,

* The temperature of direct and return water delivery and its flow rate are registered in the accounting journal only at the input and output of the water heating boiler, when the parameters of direct water are connected with the three flows water passing through the boiler, water passing through the heating system boiler and make-up water from the make-up deaerator,
* The heating system boiler is started at the beginning of the heating season, where delivery water is heated only by the steam-condensate blend returned from process equipment Direct steam lines are connected to the Boilers, but no steam is supplied, and during the heating season with the increment of heating consumption the water-heating boiler is used in the event the amount of heat-carrier is insufficient,
* In the past, the delivery water make-up amounted to 10-15 m^3/hour and more, which was mainly connected with large leakage in the heating supply pipelines to Factory No 2 as well as the unauthorized use of delivery water by outside clients, mainly its use for hot water supply needs by Factory No 2 After the heating supply pipeline was revamped and a hot water supply boiler was installed at the Factory No 2, the volume of make-up water was sharply reduced and amounted only 1 m^3/hour during the last heating season,
* The design curve of the direct and return water temperatures of the heating system is not followed For example, at ambient temperatures below minus 20^0C, the hot water temperature is 20-35^0C lower than required, which is mostly due to the fuel savings policy,
* When comparing actual (according to the data registered in the journal) temperature difference in the direct and return water lines with the design curve, we may draw preliminary conclusions, that the system is not operating properly For example, at ambient temperatures below minus 27-33^0C the temperature difference is 40-44^0C as compared with the design rated parameter of 63-72^0C This should be connected with a rather high delivery water flow rate amounting to about 500 m^3 /hour It is necessary to carry out an appropriate study during the operation of the system for the final resolution of the problem

Hot Water Supply System [HWS]

The steam-condensate blend returning from process equipment is also used as the heating carrier in the HWS Boilers Live steam pipes are connected to the Boilers, however they are not often used The hot water temperature should be maintained at the level of 60-70^0C During the measurements, the direct hot water temperature was equal to 76^0C and the temperature of the water returned to the boiler house amounted to 56^0C The *Panametrics Meter* was used for hot water flow rate measurements in the hot water supply system in order to analyze the character of water consumption in the HWS system Fig 5 1 3 shows a daily curve of water consumption

Fig 5 1 3 Water Consumption for HWS needs July 10, 1998 r



Because a single-channel meter was used to measure the flow rate, it took us two days to complete the measurements The first we measured the flow rate of hot water in the input line, the second day we measured the return water flow rate The above mentioned Fig 5 1 3 represents hot water consumption calculated as the difference between average daily consumption in the input pipeline, which amounted to 28 m^3/hour, and the results of flow rate measurements in the return pipeline According to the measurement results the water consumption variance in the feed pipeline during a 24 hours period is not very high and amounts to 26-31 m^3/hour (see Appendix IV) Such an approach results in a certain error in the evaluation of actual hot water consumption at given time Thus, the maximum consumption peak values according to the curve should be a little higher, and vice versa At the minimum hot water consumption values should be a little less than those plotted in this curve So, actual water consumption during the night hours should be 1-2 m^3/hour less than the above mentioned and 1-2 m^3/hour higher when showers are used at the end of the work shift

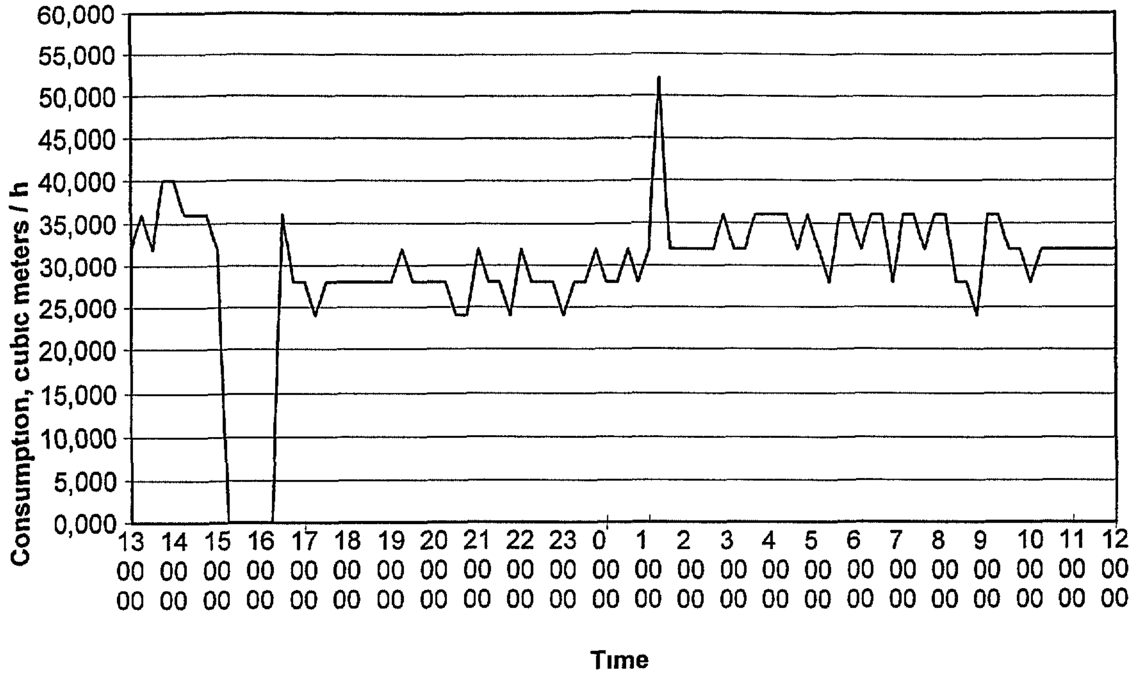
Daily hot water consumption amounts to about 114 m^3/hour The commercial cold water meter readings were also recorded during the period of measurements (see Fig 5 1 4) The daily cold water consumption amounted to 719 m^3/hour The following conclusions may be drawn according to the results of measurements

* The actual hot water consumption is not very high and is equal to 3-5 m^3/hour,
* Substantial hot water leaks in the hot water supply system take place with their relative volume equal to 30-50%, which amounts at least to 2-3 m^3/hour,
* The overrun of water circulating in the system is obvious with its volume 4-5 times exceeding actual consumption

Water Supply System

Commercial cold water meter readings were registered every 15 minutes over a 24-hour period in order to analyze the cold water consumption by the Factory As a result of these measurements a curve shown in Fig 5 1 4 was plotted

Fig 5 1 4 City Water Consumption, July 8, 1998 r



No consumption within the period of 3 15 a m - 15 14 a m is explained by the fact that a valve on the input pipeline from the City Water Supply to surge reservoirs was closed An average water consumption rate from the City Water Supply within the period of 7 p m until 3 a m , i e during the work shift amounted to 33 2 m^3/hour with an average of 30 7 m^3/hour during the night Thus, the difference between these values is water consumption for process needs - about 2 5 m^3/hour or 20 m^3 per shift

5 2 *Possible Energy Efficiency Measures*

General remarks

As a result of the energy audit opportunities to improve the energy efficiency of the Factory were found The heating and steam supply systems of the Factory provide the highest energy efficiency potential It is closely connected with technological production aspects Unfortunately, because there was a time constraint on the performance of the energy audit, the Factory was not fully operational during the audit (it was disconnected from the gas supply for two days, a low quality particle board was supplied etc) and some of the workshops were not operating at full capacity, it was not possible to carry out a more detailed study of all the systems in the Factory We were also unable to complete a fuel-energy balance for the Factory and its separate divisions, which would have provided for a more precise and detailed list of recommended energy efficient projects Due to the above factors, a limited number of measurements were made and repeated at different operation/loading parameters but did not allow us to work-out these recommendations to the level of an energy efficiency project Nevertheless, this clause includes a few proposals, which may provide for substantial energy efficient improvements However, this will require additional data, measurements and clarifications The Energy Department of the Factory may carry out the additional activities

Electric Power Supply System

It is quite clear, that if a regular electric power measuring system is used by each workshop at the Factory, it would be possible to obtain complete data on the character and parameters of energy consumption at the Factory as a whole This data is especially important for concluding electric power contracts with the utility company (probably, with several utility companies - presently, the management of the Factory considers the alternative electric power supply from the neighboring company, where a 9 MW turbo-generator should be put into operation) It would make it possible to reduce electric power bills to a very minimum by means of better distribution of the electric load at the Factory It is also important for the correct selection and proper installation of the reactive power capacitors, etc

In addition, such a system would make it easier to motivate maintenance personnel to save electric power For example, when the energy balance of the Factory was being prepared, the high electric power consumption at night was registered According to the energy balance, it could be suggested that about 80 kW of night electric power consumption is not justified This amount may be a bit lower because of the incorrect readings of the technical accounting meters installed at the Central Control room However, it is obvious that a certain excessive consumption of electric power takes place, most probably, because of the inefficient use of the lighting systems and, perhaps, the ventilation system In the event that a centralized system of accounting of electric power consumption is used, such situations could be avoided Due to the fact that the Factory has been using a data collection system from TS5000 Technical Accounting Meters, the cost of its repair and the organization of control and accounting for electric power should be rather low

Lighting System

During the visual inspection of shops No 2 and 3, after the work-shift had ended, the unjustified use of the lamps with the aggregate power of 5 kW was found This is equivalent to an excessive electric power consumption of about 10 1 kW per year or 3,000 rubles per year The organization of appropriate control over the use of the lighting system and the development of lighting energy efficient measures would allow drastic reductions in electricity bills It should be noted that the above mentioned savings do not reflect the entire energy efficient potential of the lighting system, because the initial data was the results of the visual inspection of only two workshops during one workday

Ventilation System

Presently, air ventilation and exhaust functions are provided ventilators with 37-45 kW drives designed to support a large number of process units In the present conditions, of irregular operation of process units, one possible variant to reduce electric power losses in the ventilation system is the sectioning of the exhaust ventilation system with the installation of smaller ventilators supporting individual process sectors or workshops In addition, in our view, there are inefficient design concepts relating to the mutual arrangement of the input-exhaust systems of the general ventilation system For example, in shop No 1 there are large diameter air ducts located practically nearby As a result, most of the incoming heated air is immediately sucked out by the exhaust system

Compressed Air System

About 10% of the total electric power consumption of the Factory (not considering the outside clients) is attributed to the air compressor, though the need of compressed air is not all that high The large electric power consumption is due to the fact that a 20-m3/min compressor is operating continuously during the work-shift, and since no capacity regulation functions are provided, the excessive air from the system is discharged into atmosphere Even the elimination of the leaks detected during the audit would not guarantee power savings, if the compressor is not replaced The use of a screw compressor with the capacity of 25 m^3/min is also not efficient (see, Clause 5 1) Considering current irregular air consumption, it is necessary to install a new compressor with a wide range of capacity regulation, which would provide for real economy in the compressed air system In the event that the air leaks, which according to the inspection amount to about 50%, are eliminated, it would be recommended to buy a new compressor with a capacity up to 10 m^3/min Modern compressors may be installed directly in the workshops without costly construction, so the compressor may be installed right in the workshop-end-user with possible operation through the centralized ventilation system

Taking into account the low operation time of the compressor during the year, the energy efficient project involving the replacement of the compressor has a rather long payback period Nevertheless, we still recommend replacing the existing compressor with a new one based on a scrupulous analysis of operation costs

Another potential for electric power reduction in the ventilation system would be to use smaller compressors installed directly in the workshops of the Factory, which would cover needs of compressed air of individual units Such decentralization of the compressed air system would allow matching the operation of compressors and process units using compressed air to the maximum extent

Heating System

Since the energy audit was done during the summer, it was not possible to see the heating system of the Factory in operation and to make pertinent measurements Unfortunately, a Delivery Water Register (Journal) included only water parameters relating to the water-heating boiler The parameters of the delivery water passing through the boiler or after blending with water passing through the heating-boiler are not recorded According to the data of the Register, it seems that there is excessive amount of water consumed by the heating system, since the temperature difference of the direct and return water is 1 5 times lower than the design However, this matter needs additional consideration, including appropriate measurements and calculations during the heating season

It should be noted that because of a large amount of heat returned to the boiler house with steam-condensate blend from the process units (see below), in the beginning of the heating season they have to initially operate the heating boiler and with an increased demand for heating - the water-heating boiler As a result, the heating-boiler may operate in an inefficient mode with only 2-4 of the 8 burners operating The heating-boiler seldom has 6 burners operating and only if outdoor temperatures drop below –25^{0}C This results in a drop of boiler efficiency and fuel overrun by the boiler house

Technology and Process Steam Supply - Current Status

Presently, fuel is used very inefficiently This is due to the fact that 9-10 tons of steam per hour in needed for processing, even when the steam end-users, are operating one-shift (sometimes not even a full-shift) (see Clause 3 2 2) Thus, 16 hours per day steam production is not used for the actual production output, which leads to direct fuel losses amounting now to about 2,800 thousand m^3 of natural gas per year or 840 thousand rubles ($133 6 thousands)

The continuous generation of steam without it actual being used for production purposes means that pure steam is returned to the boiler house When the end-users are operating, a steam-condensate blend is returned to the boiler house with steam constituting a major part of this blend, because there are no condensate blowdown drums installed on the impregnating lines and presses So, steam energy is used very inefficiently, for the efficiency of steam mainly relates to heat transfer during interphase transition from vapor to liquid The steam-condensate blend is returned to the boiler house 24 hours per day mainly from the textured paper impregnating line, edge-plastic and presses lines So, the savings of the above mentioned amount of fuel is possible only if the finned pipes in the drying chambers of the impregnating lines are replaced Savings can also be realize by switching to another heat-carrier for the pressing workshop, for example, oil or overheated water

The presses can use oil as the heat carrier and, in fact, two units of the Factory are now using it Oil is heated by electric power

Overheated water may also be used as the heat-carrier A 1 0 MPa pump and a steam-water heat exchanger to heat water up to 150-170^{0}C would be required for this purpose Switching to another heat-carrier would avoid unjustified steam consumption and save about 750 thousand m^3 of natural gas per year or 240 thousand rubles ($38 thousands) The feasibility study and implementation of this proposal require additional consideration taking into account all factors of influence, including such important aspects as fire safety provisions in the case that oil is used and the provision of one-phase (liquid) state of water, if it is used as heating carrier

Presently, direct low-pressure steam (up to 2 atm) is used for lumber drying The lumber drying process continuous 24 hours per day for several days It is recommended, with the aim of fuel saving, to use secondary evaporation steam from the steam-condensate blend returned after the process units to the boiler house This could be implemented directly in the boiler house using available pipelines In the event that all four dry kilns are used, the implementation of such recommendation may give the annual economy of 701 636 m^3 of natural gas or 210,856 rubles involving minimum expenses (see project No 9)

Thus, the drastic approach to the solution of the problem of economic steam usage is to use steam energy in full in the process units and to shutdown the steam supply when work stops

Perspective Technologies

Presently, the Factory plans to use decorative finishing/coating film under Western technology to coat parts of the furniture sets Under the existing technology, a number of energy-intensive process lines are used, including the section for preparation of impregnating resin, textured paper impregnating lines and the unit for rolled finishing materials with varnish coating for edges and profiles According to the currently applied technology, after finishing surfaces and edges are varnished the varnishing equipment should be rinsed In the event that the decorative film is used, the impregnating resin preparation stage, textured paper impregnating lines and the unit for rolled finishing materials with varnish coating for edges and profiles and the subsequent rinsing of equipment will be excluded from the production cycle

After the introduction of the new technology, the demand for steam, water and electric power should be sufficiently reduced (see project No 1) The annual savings of natural gas should amount to 836 5 thousand m^3 per year basing on 100 thousand m^2 with 913 thousand ruble saving, most of which relates to the reduction of raw-material consumption As a possible result of steam consumption reduction the capacity of the DKVR-20/13 boiler may become too high Considering the fact that the boiler is now operating at half of its full capacity, it is necessary to consider revamping the DKVR-6 5 boiler with the installation of additional gas burners This would allow for a more flexible and efficient heat production dependent on real loading of the process equipment now and in the future

Boiler House

As a result of a large amount of steam returned to the boiler house (mainly in the form of steam), especially during the summer, the problem of its use emerges The only consumer of the returned steam-condensate blend during this time is a feed-water deaerator and water-heating boiler of the hot water supply system

Due to the fact that, usually, the amount of returned heat greatly exceeds its possible consumption, most of this steam and steam from the secondary evaporation of steam-condensate blend is discharged to the atmosphere

Presently, as mentioned in Clause 5 1, practically all heat of the steam-condensate blend is lost, because no orifice in a large diameter pipe, which discharged steam to the atmosphere, is available

In addition, the excessive amount of heat does not stimulate the search for new energy efficiency solutions for the boiler house For example, vented steam from the treated water deaerator is not used in the summer time, although the heat exchanger for this purpose is available and is in good condition (see project No 2) Annual fuel savings may reach 613 4 thousand m^3 of natural gas or about 72 thousand rubles

Water overheating in the hot water system was observed, and the installation of the automatic temperature control system should be completed (see project No 6) After the automatic control system is in place, the annual fuel savings should amount to 296 7 thousand m^3 of natural gas, which is equivalent to 89,164 rubles per year In addition, it could be recommended to reduce the amount of circulating water in the hot water supply system by replacing the KM45/30 pump with K8/18 pump (see project No 4) The fresh water heat exchanger before the chemical water treatment facility is not operating In this case, the process flow diagram of the boiler house provides for the use of live steam for such heating, however, it would be more economic to use the secondary evaporation steam from the continuous blowdown separator, which is located 2-3 meters from the heat-exchanger This would allow savings of about 752 GCal of steam heat or 91 thousand m^3 of natural gas, which is equivalent to 27,000 rubles

The insulation of pipes in the boiler house and steam pipelines in the workshops of the Factory may provide a substantial economic effect (see project No 5) The annual savings of natural gas should be 239 46 thousand m^3 or 71 962 thousand rubles

Tests of the steam boiler demonstrated the possibility of fuel saving through reducing air suction in the furnace and in the effluent smoke ducts of the boiler (see project No 3 and 7) In this case, a 1-1 5 mm water column pressure drop in the furnace would not require additional expenses and would provide fuel saving of 107 6 thousand m^3 of natural gas or 32 336 thousand rubles per year

Electric Power Generation

Presently, the boiler house features a large steam generation capacity with steam production exceeding 70 tons of steam per hour, in contrast with current process needs of only about 9-10 tons per hour After the introduction of energy efficiency projects, this amount could be reduced to 3-4 tons per hour In this connection, it could be interesting to consider the project for the installation of a steam turbine for co-generation Considering current high prices of the electric power supplied by the Energo and relatively cheap natural gas, such a project may be implemented and is quite feasible (see project No 10)

General Remarks

Although the steam boiler KE-25-14S has not yet been in operation, in the event it is put into operation, it is recommended to replace its *BIG* injection burners, installed under the recommendations of State Gas Inspection Authorities of the Ministry of Gas Industry, with slit burners similar to the ones installed in another steam boilers This would allow for a substantial increase in efficiency (1 5-2 0%) of the boiler by means of using an air-heater This would also make it possible to prevent substantial air suction during the winter into the boiler house, as is the case now with the use of the injection burners, which takes in-take air from the boiler house

Presently, after the deaerator feed-water with a temperature of 102-104^{0}C is supplied to feed-pumps and further to the boiler's economizer The alternative scheme of regenerative feed-water heating after the treated water deaerator seems to be more efficient The advantage of such scheme is better conditions for the operation of the feed-pumps (feed-water temperature 65-75^{0}C with a more efficient operation of the boilers, because of a better cooling of effluent gases due to cooler water supplied to the economizer) The first stage (through the loop of the return delivery water) of the heating boiler may be used as a heat-exchanger for treated water heating, because even during the winter only one boiler of the two installed is used In order to implement such a scheme, more detailed calculations would be required using data on boiler design, their heating surfaces, etc Possible fuel savings may reach 30-35 thousand m^3 per year

In the event that the recommendations relating to steam savings in the process lines and during its production and transportation are implemented, the amount of steam required for process needs may be drastically reduced In this case and in the event that the co-generation project involving a steam turbine installation is implemented, it would be required to install gas burners in the KE-6 5/14 boiler and put it into operation

Water Supply System

Presently, the recycling water supply systems of the Factory intended for the cooling of air compressors and process equipment are not used, because some parts and sections of these systems are broken Project No 8 evaluates a saving potential related to the repair of the recycling water supply It should be noted that currently there are low water tariffs in the region, however, they plan to substantially increase these tariffs, so this project should be more attractive economically

5 3 *Recommended Energy Efficiency Measures*

The following tariffs as on July, 1998 were used for the purpose of energy efficiency analysis gas - 0 30052 rubles/m^3, water - 2 22 rubles/m^3 (sewage - 0 83 rubles/m^3), electric power - 0 29 rubles/kW, consumed reactive power - 0 006 rubles/kVARh

Project No 1

To use decorative film for finishing

1 <u>Savings</u>

Annual water	2,340 m^3 - 4,800 rubles ($762)
Annual electric power	69,070 kWh - 20,030 rubles ($3,180)
Annual gas	836 5 thousand m^3 - 251,400 ($39,904)
Others	- 637,000 rubles ($101,111)
Total Savings	- 913,230 ($144,957)

2 <u>Expenses</u>

Total	none

3 <u>Simple Payback period</u>

Recommendations
To switch to new finishing materials

Description
In the event that new finishing materials are used, the cost of utilities, feedstock, materials, consumables and other costs (transport, payroll, etc) should be much reduced In addition, environment pollution penalties should be cut These savings are due to the elimination of some process stages from the process-flow diagram for furniture sets production

Expected savings
The total annual savings should be about 913,320 rubles ($144,957) In this case water savings should be 2,340 m^3, electric power - 69,070 kWh and gas - 836 5 thousand m^3, which is equivalent under current tariffs to 4,800 rubles ($762), 20,030 ($3,180) and 251,400 ($39 904) correspondingly

Required investments
Taking into account the fact that procurement expenses for new finishing materials do not exceed the total cost of materials currently used now, this project may be considered as not requiring any additional investments

Payback period
A simple payback period is equal to zero

Implementation period
This project can be implemented immediately

Technical risks associated with the change of quality and/or quantity of output production
The application of new technologies should much improve the quality of commercial products

Initial data and results of estimations
The results of calculations made at the Factory during the comparative analysis of the application of new materials instead of impregnated textured paper based materials were used as initial data The estimation of unit savings per 1 m^2 of finished area was based on the assumption of 700 *"Sonet"* furniture sets output (with the coated area of 8 m^2) per month The evaluation of expected annual savings due to the application

of new materials was based on the assumption of furniture output with the total coated area of 100 thousand m^2 per year Such approach is connected with the lack of data on the nomenclature and volume of produced goods See the results of these estimations in the Table below

№	Name	Savings, rubles		Energy savings per year
		per 1 m^2	per year	
1	Feed-stock and materials	3 29	329,000	--
2	Transport costs	0 49	49,000	--
3	Payroll	1 80	180,000	--
4	Gross payroll	0 69	69,000	--
5	Electric power	0 20	20,030	69,070 kWh
6	Water	0 05	4,800	2,340 m^3
7	Heat energy	2 51	251,400	6,893 GCal
8	Penalties for environment pollution	0 10	10,000	--
	TOTAL	**9 13**	**913,230**	**--**

The saving of 6,893 GCal of heating energy is equivalent to the economy of 836 5 thousand m^3 of natural gas The design efficiency of heat generation in the boiler house was assumed to be 0 89

Considering the given total finished area of furniture sets the amount of savings should be a multiple of 100 thousand

Project No 2

The use of vented-steam from the deaerator to heat the chemically treated water

1 **Savings**

Annual gas	240 76 thousand m^3	- 72,353 ($11,48)
Total Savings		- 72,353 ($11,48)

2 **Expenses**

Total	none

3 **Simple payback period**

Recommendations
To use the vented-steam from the deaerator to heat the chemically treated water

Description
It is proposed to use the available heat exchanger to heat the chemically treated water by vented-steam from the deaerator with the aim of natural gas saving

Expected savings
Under current gas tariffs the saving of 240 76 thousand m^3 of natural gas is equivalent to 72,353 rubles ($11,485)

Required investments
This project may be considered as not requiring any additional investments

Payback period
A simple payback period is equal to zero

Implementation period
This project can be implemented after the problem of excessive heat generated in the summer time is resolved

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

Initial data and results of estimations
Presently, the vented-steam from the deaerator is discharged through a 89 mm pipe tot he atmosphere in the amount of exceeding 1 ton per hour The use of vented-steam energy to heat chemically treated water would allow to save about 1,984 0 GCal per year The efficiency of the heat exchanger was assumed to be 0 9 Thus, the total fuel saving should be 240 76 thousand m^3, which is equivalent to 72 353 rubles ($11,485) The design efficiency of fuel use was assumed to be 89%

Project No 3

The reduction of vacuum in the furnace of boiler No 3

1 **Savings**

Annual gas	107 6 thousand m^3	- 32,336 rubles ($5,133)
Total Savings		- 32,336 rubles ($5,133)

2 **Expenses**

Total	none

3 **Simple payback period**

Recommendations
To reduce vacuum in the boiler furnace

Description
It is proposed to reduce the amount of air suction in the furnace by 1-mm water column

Expected savings
Under current gas tariffs the saving of 107 6 thousand m^3 of natural gas is equivalent to 32,336 ($5,133)

Required investments
This project may be considered as not requiring any additional investments

Payback period
A simple payback period is equal to zero

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 such risks for this project

Initial data and results of estimations
According to measurements made at the boiler No 3 the possibility to increase incineration efficiency by means of reducing vacuum by 1-mm water column was established In this case the efficiency increase of 1 4 per cent may be obtained According to data presented by the Factory about 7 685 thousand m^3 of gas was consumed by boilers DKVR-20/13 in 1997 A 1 4% increase of efficiency would result in the annual gas savings of 107 6 thousand m^3, which is equivalent to 32,336 ($5,133)

Project No 4

1 <u>Savings</u>

Annual electric power 61,3 thousand kWh - 17 782 rubles ($2,823)
Annual gas - 63,890 ($10 140)
Total Savings - 81 672 ($12 963)

2 <u>Expenses</u>

Pump K8/18 with a motor 1,800 rubles ($286)
Total 1,800 rubles ($286)

3 <u>Simple Payback period</u>

Recommendations
To replace the pumps of the hot water supply [HWS] in the recycling line of the hot water system

Description
In order to reduce hot water consumption in the recycling line of the hot water system, it is proposed to replace one of the KM45/30 pumps with a lower capacity pump, for example, K8/18 with the rated capacity of 8 m^3/hour and head 18 m water column The replaced pump may be used for another purpose

Expected savings
Under current electric power tariffs the total annual saving of 61,320 kWh should be equivalent to about 17 782 rubles ($2,823) and the annual gas saving of 212 6 thousand m^3 - 63,890 ($10 140)

Required investments
The price of the pump K8/18 with a 1 5 kW motor is 1,800 rubles ($286), including V A T

Payback period
A simple payback period is equal to 1 month The scale of the project does not require the estimation of internal repayment 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 such risks for this project

Initial data and results of estimations
The replacement of the HWS pump with a lower capacity pump should result in a drop of consumed power from 8 3 kW to 12 3 kW which would allow for the annual electric power savings of 61,320 kWh, which in currently electric power prices is equal to 17 782 rubles ($2,823) In the event that recycling water flow rate is reduces, the amount of heat energy for the additional heating of hot water in the return line up to the temperature of water in the feed-line (by 10-15□C) If water consumption is reduced from 28 m^3/hour to 8 m^3/hour, the heating energy saving is about 0 2 Cal/hour or 1,752 GCal/year Thus, the total fuel savings are 212 6 thousand m^3, which is equal to 63,890 ($10 140) The design efficiency of fuel use was assumed to be 89%

Project No 5

The insulation of non-insulated pipes

1 Savings

Annual gas	239 46 thousand m^3 - 71 962 rubles ($11,422)
Total Savings	- 71 962 rubles ($11,422)

2 Expenses (including V A T)

Mineral wool	2,400 rubles ($381)
Asphalt paper	600 rubles ($95)
Insulating works	1,800 rubles ($285)
Total	4,800 rubles ($761)

3 Simple payback period

Recommendations
To insulate non-insulated pipeline sections in the boiler house and the pressing section of shop No 1

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

Expected savings
Under current gas tariffs the saving of 239 46 thousand m^3 of natural gas is equivalent to 71 962 rubles ($11,422)

Required investments
The insulation of the non-insulated pipe sections with the total length of 480 m would requires about 5 m^3 of mineral wool and 200 m^2 of asphalt paper The price of the insulating materials (mineral wool - 2,400 rubles ($381) and asphalt paper - 600 rubles ($95) and insulating works (assuming a factor of 0 6 of the total price of material costs) is about 4,800 rubles ($761), including V A T

Payback period
A simple payback period is equal to 1 month The scale of the project does not require the calculation of IRR

Implementation period
This project can be implemented immediately It should be noted, however, that the expected efficiency of the project may be reached only if the problem of excessive heat of returned steam-condensate blend during the summer is resolved, see Clause 5 2

Technical risks associated with the change of quality and/or quantity of output production
There are no such 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 pipelines in the boiler house and the pressing section of shop No 1 were used as initial data (see Appendix VII) The total heat losses are equal to 329 4 kW The economic thickness of insulation for the given type of pipelines is in the range of 30 - 50 mm After insulation is applied the total heat losses through the insulated pipelines should amount to about 28 7 kW Considering the operation of separate systems the annual heat savings is 2,291 kWh

Thus, the insulation of the pipelines would save about 239 46 thousand m^3 - 71 962 rubles ($11,422) The design efficiency of fuel use was assumed to be 89% 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

To install an Automatic Control System at the HWS Boiler

1 <u>Savings</u>

Annual gas	229 56 thousand m^3 - 89 164 rubles ($14,153)
Total Savings	- 89 164 rubles ($14,153)

2 <u>Expenses</u>

Total	5,800 rubles ($794)

3 <u>Simple payback period</u>

Recommendations
To install the Automatic Control System at the Hot Water Boiler

Description
It is proposed to install the Automatic Control System at the Hot Water Boiler with the aim of maintaining hot water temperature after the boiler and decreasing inefficient steam use

Expected savings
Under current gas tariffs the saving of 229 56 thousand m^3 is equivalent to 89 164 rubles ($14,153)

Required investments
The estimated price of the installation of the Automatic Control System at the HWS boiler is about 5,00 rubles ($794), including V A T This price was provided by the manufactures

Payback period
A simple payback period is equal to 1 month The scale of the project does not require the calculation of 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 such risks for this project

Initial data and results of estimations
According to the results of visual inspection the temperature of hot water supplied to the end-users was found to be 10-15^{0}C higher than rated parameters Due to that heat energy overrun for hot water preparation is observed The measured daily flow rate of the recycle water is 670 m^3 The annual energy savings should be as follows

$Q = 670\ m^3 \times 365\ days \times 10^0C = 2{,}445$ GCal,

Which is equivalent to the saving of 296 7 thousand m^3 of gas (estimated efficiency assumed to be equal to 89%) The annual gas savings in terms of money is 89 164 rubles ($14,153)

Project No 7

To reduce air suction in the Boiler No 3

1 **Savings**

Annual gas	99 9 thousand m^3 - 30,027 rubles ($4,766)
Total Savings	- 30,027 rubles ($4,766)

2 **Expenses**

Repair/restoration works	5,000 ($794)
Total	5,000 rubles ($794)

3 **Simple payback period**

Recommendations
To reduce air suction in the effluent chimney gas duct

Description
It is proposed to improve gas sealing of boilers by means of sealing hatches and repairing cracks

Expected savings
Under current gas tariffs the saving of 99 9 thousand m^3 is equivalent to 30,027 rubles ($4,766)

Required investments
The estimated price of repair works is about 5,000 rubles ($794), including V A T

Payback period
A simple payback period is equal to 2 months The scale of the project does not require the calculation of IRR

Implementation period
This project can be implemented immediately in the course of annual planned repair works

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

Initial data and results of estimations
According to measurements made at the boiler No 3 the air suction is equal to 95 per cent, which leads to increased heat losses with effluent gases A 50% reduction of air suction would increase the boiler efficiency by 1 3% In this case the total fuel saving would amount to 99 9 thousand m^3 - 30,027 rubles ($4,766)

Project No 8

To make a water recycle system for the cooling of air compressors and the impregnating line

1 Savings

Annual water	7,438 m^3 - 15 248 rubles ($2,420)
Additional power consumption	20 160 kWh - 5,846 rubles ($928)
Total Savings	9,402 rubles ($1,492)

2 Expenses

Total	9,000 rubles ($1,429)

3 Simple payback period

Recommendations
To restore the recycling water cooling system for the air compressors and impregnating units with the installation of new pumps

Description
In order to restore the recycling system it is necessary to repair pipelines of the recycling water cooling system and to replace power K-90/30 pumps with lower capacity pumps K-20/30 with the drive capacity 5 5 kW each

Expected savings
Under current water tariffs the saving of 7,438 m^3 of water allowing for the additional electric power consumption by recycling water pumps would give 9 402 rubles ($1,492)

Required investments
The estimated price of the two K-20/30 pumps) is about 6,000 rubles, including V A T Repair costs to restore the recycling water system are estimated to be about 3,000 rubles Thus, the total costs relating to the project are equal to 9,000 rubles ($1,492)

Payback period
A simple payback period is equal to 12 months The scale of the project does not require the calculation of 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 such risks for this project

Initial data and results of estimations
Presently, the piston air compressor is operating about 8 hours per day The flow rate of cooling water through the intermediary and end coolers is 5 1 m^3/hour Considering the irregular operation mode of the impregnation units the amount of cooling water is assumed basing on the operation of one KUB unit for 8 hours during one shift Water consumption per one unit is 0 37 m^3/hour Taking into account the fact that the water-cooled compressor is operating only during the summer, the annual water consumption of the cooling systems of the air compressors and impregnating process lines is about 7,748 m^3 Considering make-up water consumption (assumed to be about 4%), the restoration of the recycling cooling water system would allow to save 7,438 m^3 of water

Under current water tariffs and allowing for water-usage and sewage-usage payments the resulting savings should be equal to 15, 248 rubles ($2,420)
The additional annual electric power consumption for the operation of water cooling system pumps is estimated to be 20 160 kWh - 5,846 rubles ($928)
Thus, in the event that the recycling water cooling system is put into operation, the total savings should be 9,402 ($1,492)

Project No 9

To use a steam-condensate blends in dry kilns

1 Savings

Annual gas	701 636 thousand m^3 - 210,856 rubles ($33,470)
Total Savings	- 210,856 rubles ($33,470)

2 Expenses

Total	12,600 rubles ($2,000)

3 Simple payback period

Recommendations
To use passing steam and secondary evaporation steam after process units using high pressure steam (presses and impregnating lines) as heating carrier in the dry kilns

Description
In order to save live steam, it is proposed to use separated passing steam of the steam-condensate blend after process units as heating carrier in the dry kilns

Expected savings
The use of the passing steam in the dry kilns is equivalent to the saving of 701 636 thousand m^3 - 210,856 rubles ($33,470)

Required investments
In order to organize the use of such steam in the dry kilns it is necessary just to pass the steam-condensate blend through the separator in the steam supply line to the dry kilns Project investment should be 12,600 ($2,000)

Payback period
A simple payback period is equal to 1 month

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 such risks for this project

Initial data and results of estimations
The daily steam supply to the presses and impregnating lines is about 6 tons In the event that all four dry kilns are operating their aggregate consumption is about 1 ton per hour The pressure of returned steam condensate blend at the boiler input is 3 atm, in contrast to 2 atm required for the dry kilns Thus, a part of passing steam may be used in the heat-exchangers of the dry-kilns, which should give the annual heat energy saving of 5,782 GCal or 701 636 thousand m^3 - 210,856 rubles ($33,470) The design efficiency was assumed to be 0 89

Project No 10

To install a steam co-generation turbine

1 <u>Savings</u>
Total 7,160 thousand rubles ($1,137 thousands)

2 <u>Expenses (including V A T)</u>
Total 12,600,000 rubles ($2,000,000)

3 <u>Simple payback period</u>

Recommendations
To install the steam co-generation turbine in the boiler house of the Factory with the aim of generating electric power for the needs of the Factory and sales to the outside clients

Description
Considering excessive steam capacity of the boiler house it is proposed to install the steam co-generation turbine in the boiler house with the aim of generating electric power In this case the factory may sell electric power to the outside clients

Expected savings
Under current gas and electric power tariffs the installation of the co-generation turbine should give the annul profit of about 7,160,000 rubles ($1,137,000)

Required investments
The installation of the turbine and support equipment should cost $2,000,000 This amount includes all construction-assembly costs

Payback period
A simple payback period is equal to 1 year and 10 months The analysis of a net present value of the project is provided in Appendix X

Implementation period
This project can be implemented after the problem of the additional electric power supply is resolved

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

Initial data and results of estimations
The boiler house has boilers with the aggregate steam capacity of 70 tons per hour, in contrast with current process and other needs amounting only to about 9 tons per hour After the introduction of energy efficiency projects this amount could be reduced to 3 tons per hour, which could be provided by the DKVR-6 5 boiler So, it is recommended to use the steam of the three steam boilers with the capacity of 65 tons per hour for co-generation in a condensate-steam turbine, for example, K-12-10P ("Kaluga Turbine Manufactures") The recommended turbine uses 1 MPa saturated steam The turbine's capacity is equal to 11 MW which makes it possible to cover Factory's needs in electric power and sell it to the outside clients The annual electric power production could reach 96,360 MWh In the event that power consumption of the Factory is maintained at the level of 1997 and excessive electric power is sold to the outside clients under prices lower than Energo tariffs the economy should be about 20,570 thousand rubles ($3,265,00)

The following maintenance costs would be required for this project
gas 44,116 thousand m^3 - 13,257 7 thousand rubles ($2,104,400)
other expense 150 thousand rubles ($23,800)

Thus, the annual average saving is about 7,160 thousand rubles ($1,137 thousands)

APPENDIX

Appendix 1 PRODUCTION OUTPUT OF "NOVOSIBIRSKMEBEL" IN 1997

№	Goods	Unit	Production output per month, 1997												Annual
			1	2	3	4	5	6	7	8	9	10	11	12	
1	Furniture														
	Furniture sets	set	452	700	451	200	250	300	351	100	100	300	101	300	3,605
	antechamber furniture sets	set	200	380	49	100	--	--	--	150	--	-	26	49	954
	wardrobe-shelves	pcs	400	380	333	251	250	203	101	190	286	302	300	300	3,296
	wardrobes - total	pcs	29	41	21	203	6	16	227	506	8	18	430	123	1,628
	kitchen cabinet	pcs	--	--	4	2	1	1	6	2	3	3	5	4	31
	tables - total	pcs	10	10	9	--	--	--	20	--	120	--	--	--	169
2	Other domestic items	th rub	0 1	0 2	0 2	0 1	0 5	1 1	--	2 0	--	--	0 3	--	4 5
3	Services to population	th rub	15	10	8	2	13	7	3	5	1	3	4	10	81
4	Components	th rub	--	0 9					5 9	--		1 6	0 6	31 5	40 5
5	Wood processing	th rub	55 6	52 4	13 4	79	17	87	74	69 8	68 3	32 5	57 5	59 9	668 4
6	Decorative panels	th rub	11 7	22 1	14 5	2 0	4 6	38 2	4 7	3 9	1 6	6 2	10 3	12	131 8
7	Other items	th rub	57 5	60	44 8	25 8	10 3	61 5	28	15 4	10 5	12	12 5	33	371 3
8	Heating energy (outside clients)	GCal	947	1,031	1,107	577	200	415	150	243	254	254	1,167	1,534	7,879

APPENDIX II FUEL-ENERGY CONSUMPTION BY “NOVOSIBIRSKMEBEL” IN 1997

№	Utilities	Unit	Jan	Feb	Mrch	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Per year
1	Natural gas	t stnd,f	1715	1596	1190	819	345	591	446	707	262	830	1640	1823	11964
		th m^3	1491	1388	1035	712	300	514	388	615	228	722	1426	1585	**10404,38**
	tariff	rub/m^3	0,2961	0,2909	0,2909	0,2906	0,2913	0,2906	0,2942	0,3005	0,2935	0,2922	0,2913	0,2993	
	paid for 1997	th rub	441,66	403,80	301,08	206,96	87,40	149,34	114,10	184,74	66,86	210,90	415,45	474,57	**3056,85**
2	Elec power	MW h	700	990	787	608	230	387	230	256	280	416	606	780	**6270,00**
	tariff	rub /kW h	0,287	0,287	0,287	0,305	0,305	0,305	0,305	0,305	0,305	0,305	0,305	0,305	
	paid for 1997	th rub	200,90	284,13	225,87	185,44	70,15	118,04	70,15	78,08	85,40	126,88	184,83	237,90	**1867,76**
	reactive power	t kVARh	820	590	844	456	159	389	80	323	247	343	565	734	**5550**
	tariff	r /kVARh	0,006	0,006	0,006	0,006	0,006	0,006	0,006	0,006	0,006	0,006	0,006	0,006	
	paid for 1997	th rub	4,92	3,54	5,06	2,74	0,95	2,33	0,48	1,94	1,48	2,06	3,39	4,40	**33,30**
	unused el power	t kW h			423,0			815,0			784,0			348	**2370,0**
	tariff	rub /kW h	0,1262	0,1262	0,1262	0,1262	0,1262	0,1262	0,1262	0,1262	0,1262	0,1262	0,1262	0,1262	
	paid for 1997	th rub	0,00	0,00	53,37	0,00	0,00	102,82	0,00	0,00	98,91	0,00	0,00	43,90	**299,00**
	Total	th rub	205,82	287,67	284,30	188,18	71,10	223,19	70,63	80,02	185,79	128,94	188,22	286,21	**2200,06**
3	City water														
	consumption	th m^3	61	60	62	59	58	55	57	52	55	62	47	41	669
	tariff	rub/m^3	0,904	0,904	0,904	0,904	0,904	0,904	0,904	0,904	0,904	0,904	0,904	0,904	
	paid for 1997	th rub	55,14	54,24	56,05	53,34	52,43	49,72	51,53	47,01	49,72	56,05	42,49	37,06	604,78
	allocated	th m^3	45	48	40	42	46	48	32	23	27	11	15	13	390
	tariff	rub/m^3	0,687	0,687	0,687	0,687	0,687	0,687	0,687	0,687	0,687	0,687	0,687	0,687	2,324
	paid for 1997	th rub	30,92	32,98	27,48	28,85	31,60	32,98	21,98	15,80	18,55	7,56	10,31	8,93	267,93
	total		86,06	87,22	83,53	82,19	84,03	82,70	73,51	62,81	68,27	63,61	52,79	46,00	872,71

APPENDIX III HEATING ENERGY GENERATED BY"NOVOSIBIRSKMEBEL" IN 1997

№	Utilities	Unit	Jan	Feb	Mrch	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Per year
1	**Heating energy, including**	GCal	10045,0	7894,0	10206,0	8275,0	2872,0	5031,0	4124,0	4786,0	3913,0	5738,0	8231,0	8853,0	79968,0
	to outside clients	GCal	947	1031,0	1107,0	577,0	200,0	415,0	150,0	243,0	254,0	254,0	1167,0	1534,0	7879,0
	for own needs	GCal	9098,0	6863,0	9099,0	7698,0	2672,0	4616,0	3974,0	4543,0	3659,0	5484,0	7064,0	7319,0	72089,0

APPENDIX IV DAILY POWER CONSUMPTION CURVES FO THE MAIN CUSTOMERS OF "NOVOSIBIRSKMEBEL"

Fig IV-1 Total electric power consumption by the Factory (including outside clients), July 6-7, 1998

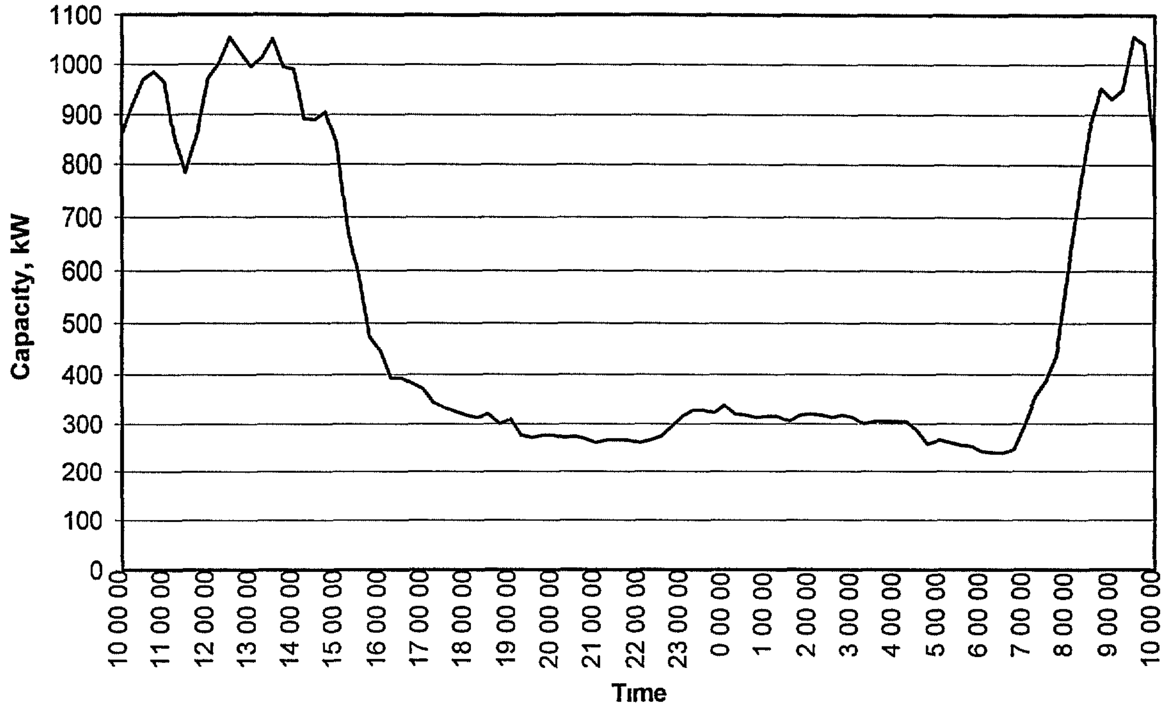


Fig IV-2 Load at TP-1, July 6-7, 1998

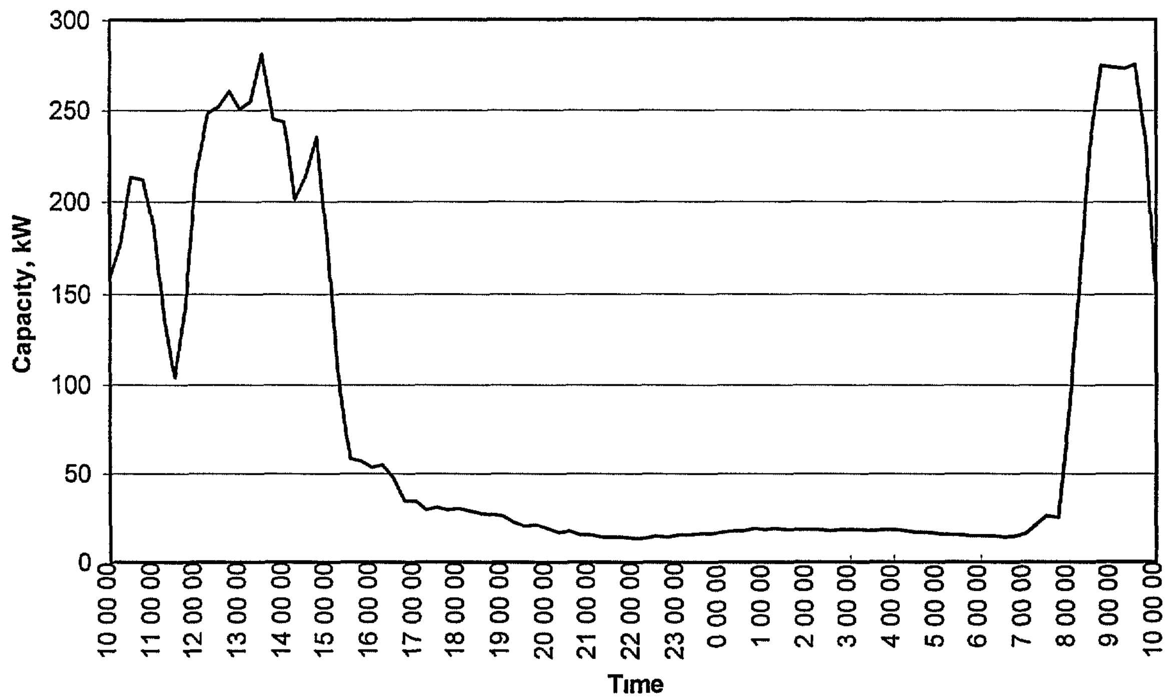


Fig IV-3 Power consumption by the piston compressor, July 6-7, 1998

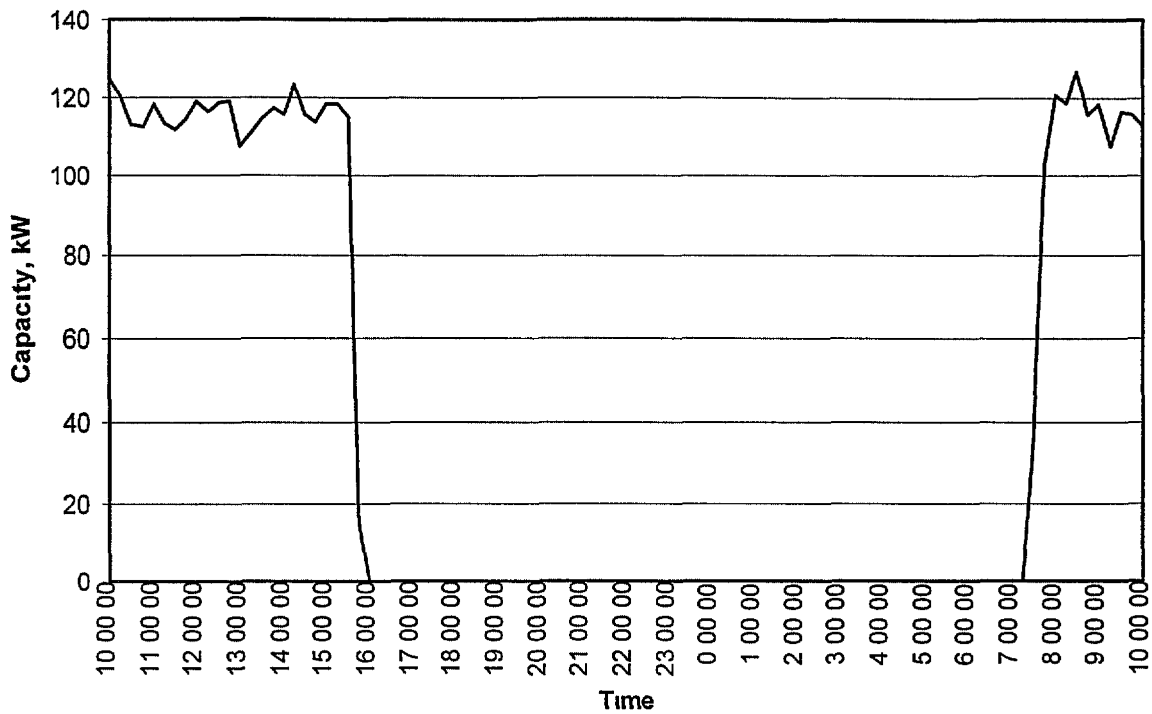


Fig IV-4 Electric power consumption by the Boiler House, July 6-7, 1998

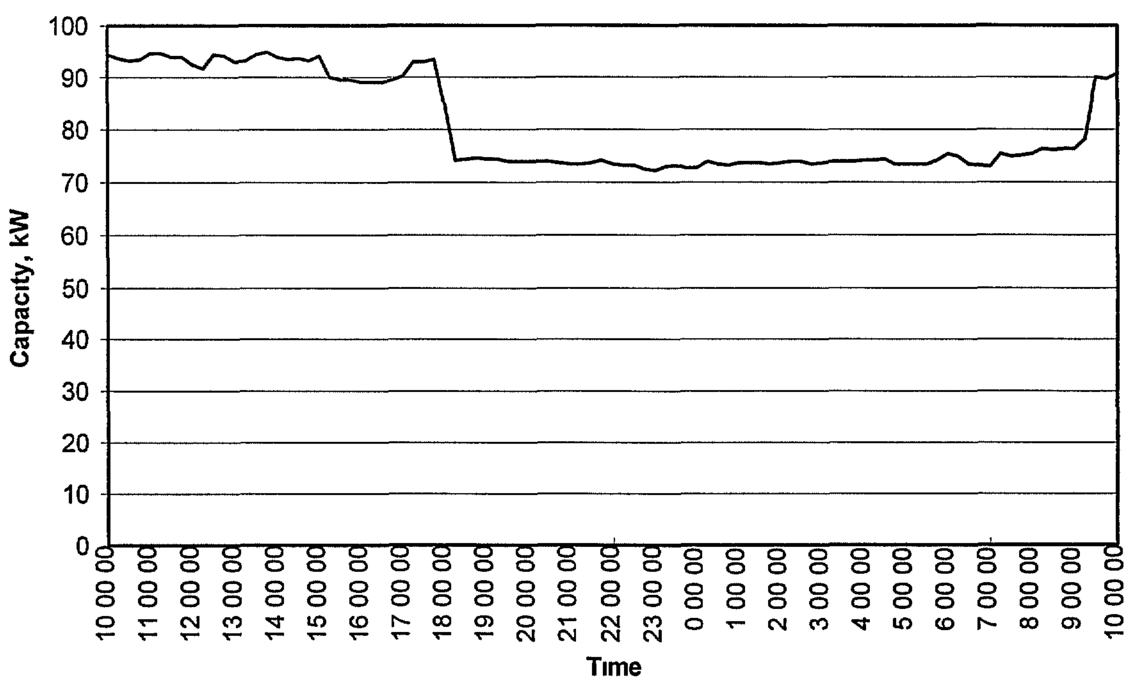


Fig IV-5 Power consumption by City Water pumps
July 6-7, 1998

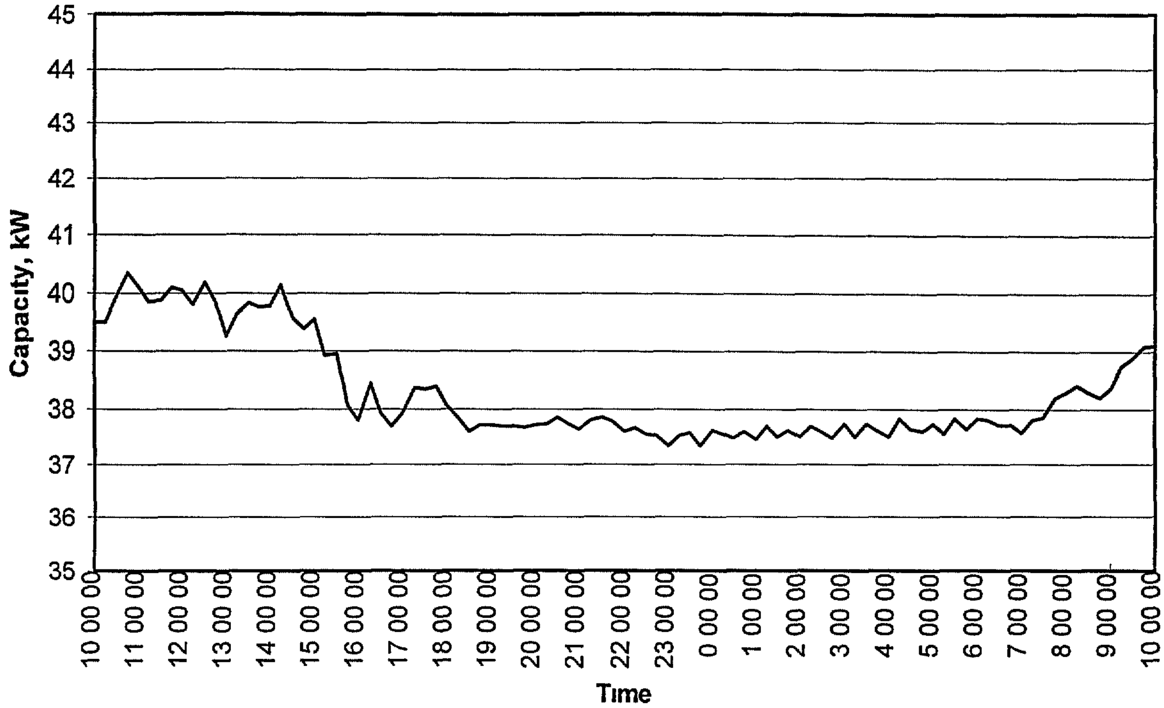
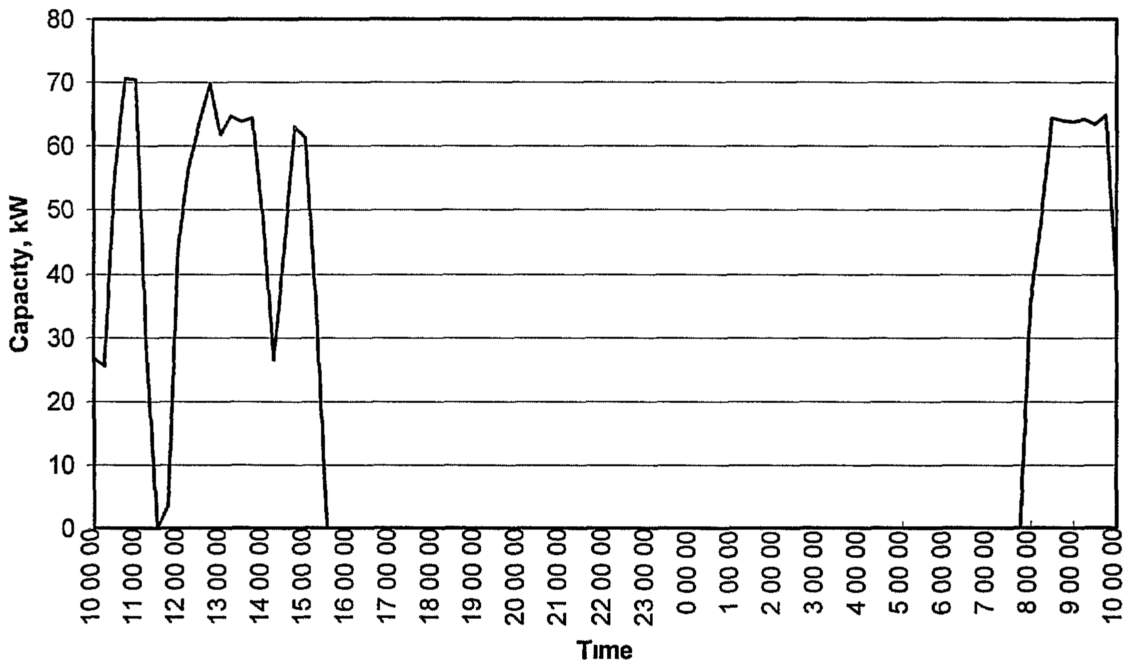
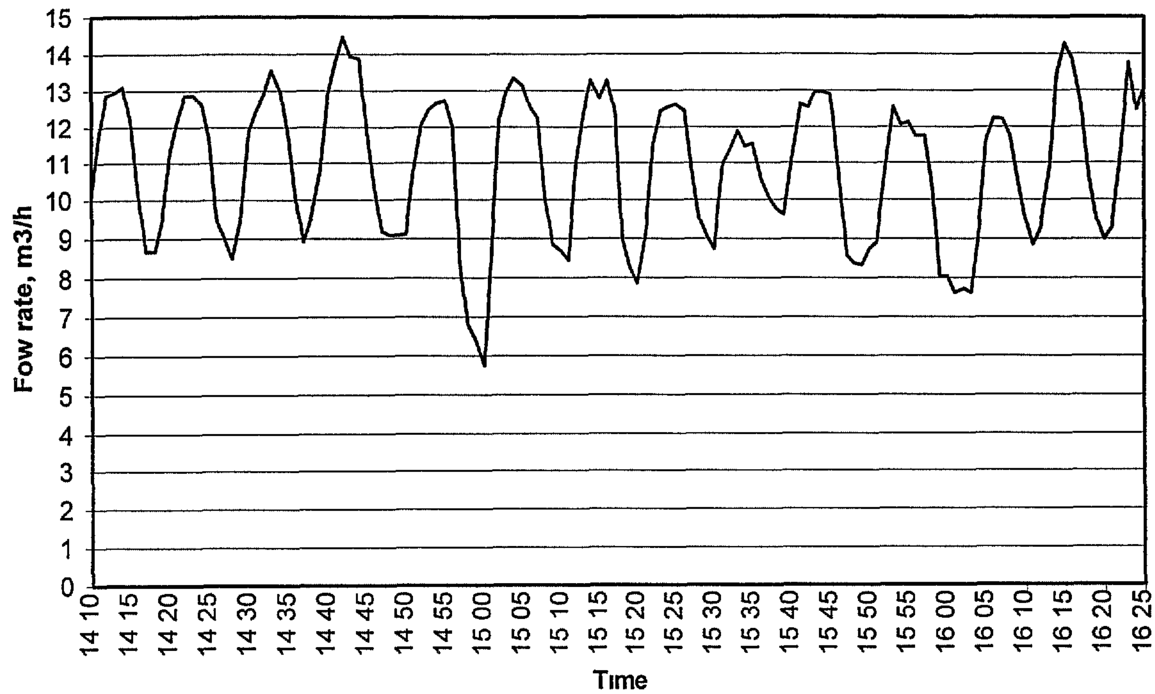


Fig IV-6 Power consumption by electric equipment installed on the ventilation rack, July 6-7, 1998



APPENDIX V DAILY WATER FLOW RATE IN THE FEED-LINE OF THE HOT WATER SUPPLY SYSTEM, JULY 9, 1997



APPENDIX VI DATA ON HEAT-SCREENS AND INPUT VENTILATION UNITS

№	System	Location	Calorifer			Ventilator			
			Type	heat-carrier	P, Bar	type	amount, pcs	flow rate, m^3/h	drives capacity, kW
Heat-screens									
1	ВТЗ-1	Passage, shop 1-2	--	water	8	Ц4-70 №6,3	2	12,620	5 5
2	ВТЗ-2	Gates, shop 1	--	water	8	Ц4-70 № 6	2	5,500	2 2
3	ВТЗ-3	Gates, shop 2	--	water	8	Ц4-70 № 6,3	2	5,500	2 2
4	ВТЗ-4	Gates, shop 1	--	water	8	Ц4-70 № 6,3	2	5,500	2 2
5	ВТЗ-5	Gates, shop 1	--	water	8	Ц4-70 № 6,3	2	5,500	2 2
6	ВТЗ-6	Finished product warehouse	--		8	Ц4-70 № 6,3	2	5,500	2 2
7	ВТЗ-7	Glass warehouse	--	water	8	Ц4-70 № 6,3	2	5,500	2 2
Input ventilation system									
1	П-1	shop 2	КВС-12П	water	6	Ц4-70 №12,5	1	42,800	17 0
2	П-2	shop 2	КВС-12П	water	6	Ц4-70 № 10	1	12,500	5 5
3	П-3	shop 2	КВС-11П	water	6	Ц4-70 № 12,5	1	37,230	18 5
4	П-4	shop 2	КВС-11П	water	6	Ц4-70 №12,5	1	41,120	17 0
5	П-5	shop 2	КВС-11П	water	6	Ц4-70 № 12,5	1	40,500	18 5
6	П-6	shop 2	КВС-12П	water	6	Ц4-70 № 10	1	25,000	7 5
7	П-1	shop 3	КСКЗ-16	water	6	Ц4-70 № 10	2	18,230	11 0
8	П-27	shop 1, drying section	КСКЗ-16	water	6	Ц4-76 № 12	1	42,870	17 0
9	П-28	shop 1, drying section	--	water	6	Ц4-70 № 8	1	14,240	5 5
10	П-29	shop 1, drying section	--	water	6	Ц9-57 № 8	1	16,900	7 5
11	П-30	shop 1, drying section	--	water	6	Ц4-76 № 10	1	37,600	17 0
12	П-20	shop 1, mezzanine	--	water	6	Ц4-70 № 10	1	17,000	11 0
13	П-21	shop 1, mezzanine	--	water	6	Ц4-76 № 12,5	1	37,000	18 5
14	П-22	shop 1, mezzanine	--	water	6	Ц4-76 № 12,5	1	37,000	18 5
15	П-23	shop 1, mezzanine	--	water	6	Ц4-76 № 12,5	1	37,000	18 5
16	П-24	shop 1, mezzanine	--	water	6	Ц4-76 № 12,5	1	37,000	22 0

APPENDIX VII LIST OF SUCTION VENTILATION SYSTEMS

№	System	Location	Ventilator			
			type	amount	air flow rate, m^3/h	drives capacity, kW
1	ПТ-1	ventilation rack, shop №1, level 11 9 m	ВЦП-6-45	1	18275	37,0
			ВЦП-6-45	1	18275	45,0
2	ПТ-2	ventilation rack, shop №1, level 12 5 m	ВЦП-6-45	1	21800	37,0
			ВЦП-6-45	1	21825	37 0
3	ПТ-3	ventilation rack, shop №1, level 12 5 m	ВЦП-6-45	1	18120	37,0
			ВЦП-6-45	1	18120	37,0
4	ПТ-4	ventilation rack, shop №1, level 12 5 m	ВЦП-6-45	1	9565	37,0
			ВЦП-6-45	1	9595	37,0
5	ПТ-5	ventilation rack, shop №1, level 11 9 m	ВЦП-6-45	1	16110	37,0
			ВЦП-6-45	1	16260	37,0
6	ПТ-3, ПТ-4	ventilation rack, shop №2, level 11 9 m	ЦП-7-40	1	12530	30,0
			ЦП-7-40	1	14300	37,0
7	ПТ-5, ПТ-6	ventilation rack, shop №2, level 11 9 m	ЦП-7-40	1	12585	37,0
			ЦП-7-40	1	10600	30,0
8	ПТ-9,ПТ-10	ventilation rack, shop №2, level 11 9 m	ВЦП-6-45	2	11750	37,0
			ЦП-7-40	1	8190	22,0
9	ПТ-2	ventilation rack, shop №2, level 11 9 m	ЦП-7-40	1	15095	30,0
10	A-4	ventilation rack, shop №2, level 11 9 m	ВЦП-6-45	1	9780	45,0
11	ПТ-24	ventilation rack, shop №2, level 11 9 m	ЦП-7-40	1	9900	30,0
12	ПТ-25	ventilation rack, shop №2, level 11 9 m	ЦП-7-40	1	11660	30,0
13	ПТ-14	ventilation rack, shop №2, level 11 9 m	ЦП-7-40	1	12410	40,0
14	A-6	ventilation rack, shop №2, level 11 9 m	ЦП-7-40	1	10380	40,0
15	ПТ-8	ventilation rack, shop №2, level 11 9 m	ЦП-7-40	1	7770	22,0
16	ПТН-5	main ventilation rack, sub-rack, level 0,8 m	ЦП-7-40	1	13525	30,0
17	ПТ-1	trucks outdoors, level 1,2 m	ВЦП-6-45	1	8470	22,0
18	B-1	in shop № 1, mezzanine	Ц4-70	1	19400	7,5
19	B-2	in shop № 1, mezzanine	Ц4-70	1	19825	7,5

№	System	Location	Ventilator

№	System	Location	Ventilator			
			type	amount	air flow rate, m^3/h	drives capacity, kW
20	B-3	in shop № 1, mezzanine	Ц4-70	1	19160	7,5
21	B-4	in shop № 1, mezzanine	Ц4-70	1	23660	11,0
22	B-5	in shop № 1, mezzanine	Ц4-70	1	18465	4,0
23	B-2	shop № 1 wood drying section, level 5,0	Ц4-70	1	26075	10,0
24	B-15	shop № 1 wood drying section, level 5,0	Ц4-70	1	40650	10,0
25	B-1	laundry	Ц4-70	1	19700	7,5
26	no data	impregnation line	Ц3-04	1	26000	4,5
27	no data	domestic premises on the roof, level 12 0	КЦ3-90	1	5800	1,0
28	no data	from gage-profile machines		1		
29	no data	shop № 1 on the roof, level 13,0	ВЦ4-70	1	5825	5,5
30	no data	shop № 1 acid batteries charging section on the roof, level 11,5	ВЦ4-70	1	5775	2,8
31	no data	synthetic veneer production section, main building, roof, level 12,0 m	КЦ4-84	1	17500	2,2
32	no data	storage , resin preparation section on the roof, lev 11,0	КЦ3-90	1	11800	1,7
33	B-1	main building, paper impregnation in the shop, lev 3,5 m	Ц14-46	1	22355	12,0
34	no data	main building, impregnation line on the roof, lev 11,0 m	КЦ4-84	1	17500	2 2
35	B-14	main building, edge plastic finishing	Ц4-70	1	15950	7,5
36	no data	main building,, synthetic veneer cutting sec on the roof , level 12,0 m	КЦ-3-70	1	5800	1,0
37	no data	main building,, formalin temporary storage in the shop, level 5,0	Ц4-70	1	12900	4,0
38	no data	mezzanine № 2	Ц4-70	1	10900	4,0
39	no data	resin preparation	Ц4-70	1	3800	2,8
40	B-13		Ц4-70	1	13800	5,5
41	B-12	edge plastic workshop	Ц4-70	1	14650	5,5
42	B-16	main building, nitrate-dope NTs-218 preparation section	Ц4-70	1	3800	0,8
43	B-17	main building , mezzanine , level 5 m	Ц4-70	1	2870	0,75
44	B-16	main building, nitrate-dope preparation section	Ц4-70	1	3800	0,8
45	no data	acetone pumping section	Ц4-70	1	3750	0,75

					m³/h	kW
46	B-18	acetone purification	Ц4-70	1	2850	0,75
47	AC-1	cutting of corrugated cardboard	Ц4-70	1	4350	4,0
48	no data	dyeing chamber in the shop, level 13 m	Ц4-70	1	15020	7,5
49	no data	main building varnishing machine in the shop, level 5,0 m	ВЦ4-70	1	5780	7,5
50	no data	shop № 3 , DURR line, outdoors, level 0,0	ЦП7-40	1	9230	22,0
51	B-2	shop № 3 , DURR line, on the chamber, level 6, 5 m	н/д	1	3775	1,1
52	no data	DURR line, level 1,6 m	н/д	1		
53	ПТ-3	shop № 3, line MLP, mezzanine	Ц4-70	1	6200	4,0
54	B-1	shop № 3, line MLP, mezzanine	Ц4-70	1	16800	7,5
55	B-4	shop № 3, line ДЮРР, mezzanine	Ц3-04	1	25000	2,8
56	B-2	shop № 3, line MLP, mezzanine	Ц4-70	1	16275	7,5
57	no data	truck-transport department	Ц4-70	1	5500	22
58	no data	truck-transport department, aggregate sector	Ц4-70	1		0,37
59	no data	truck-transport department, metal-processing sec mezzanine	Ц4-70	1	450	0,4
60		truck-transport department	Ц4-70			0,37
61	B-1	truck-transport department, domestic premises	Ц4-70	1	350	0,12
62	B-2	truck-transport department, domestic premises, on the wall, level 5,860 m	Ц4-70	1	1370	0,25
63	B-3	truck-transport department	Ц4-70	1	975	0,25
64	B-7	truck-transport department, battery section	Ц4-70	1	650	0,37
65	B-1	truck-transport department, warm parking, level 8,0	КЦ3-90	1	3200	0,27
66	B-2	truck-transport department, warm parking on the roof , level 8,0 m	КЦ3-90	1	3200	0,27
67	B-3	truck-transport department, warm parking on the roof, level 8,0 m	КЦ3-90	1	3200	0,27
68	no data	truck-transport department, warm parking on the roof, level 8,0 m	КЦ3-90	1	11800	2,2
69	no data	truck-transport department, warm parking on the roof, level 8,0 m	КЦ3-90	1	11800	2,2
70	no data	truck-transport department, warm parking on the roof, level 8,0 m	КЦ3-90	1	11800	2,2
71	no data	transport department, battery workshop	Ц4-70	1		3,0

№	System	Location	Ventilator			
			type	amount	air flow rate, m^3/h	drives capacity, kW
72	no data	transport department, car wash, on the roof, level 8 0	КЦ3-90	1	11800	2,2
73	no data	transport department, car wash, on the roof, level 8,0	КЦ3-90	1	11800	2,2
74	В-1	transport department, car wash, on the roof, level 8,0	КЦ3-90	1	11800	2,2
75	no data	Storage for flammable liquids	Ц14-46	1	6500	5,5
76	no data	Storage for flammable liquids	Ц14-46	1	7800	5,5
77	no data	boiler house, welding unit	ВЦ4-70	1	2300	0,75
78	no data	compressor room, compressor	КЦ3-90	1	11800	2,9
79	no data	repair-mechanical workshop, outdoors	Ц4-70	1	2200	3,0
80	no data	repair-mechanical workshop, garage	Ц4-70	1	2100	2,2
81	no data	electric workshop, on the roof, level 8,0 m	КЦ3-90	1	3200	0,27
82	no data	repair-mechanical workshop (collar production section)	Ц4-70	1	4900	2,2
83	no data	repair-mechanical workshop	ЦП-7-40	1	6200	5,5
84	no data	repair-mechanical workshop, forging shop	Ц4-70	1	2100	0,75
85	no data	repair-mechanical workshop, from metal-processing equipment	Ц4-70	1	3350	5,5
86	no data	electric workshop, winding/coil section	Ц4-70	1	10900	5,5
87	no data	auxiliary workshop, section for abrasive paper cutting, outdoors, level 1,0 m	Ц4-70	1	6309	2,2
88	no data	auxiliary workshop, tool section	Ц4-70	1	4760	30,0
89	no data	auxiliary workshop, tool preparation section , outdoors, level 0,5 m	Ц4-70	1	2918	0,5
90	no data	main building, welding shop, tool section, on the roof, level 12 0 m	Ц4-70	1	2918	0,5

APPENDIX VI. HEAT LOSSES FROM UNINSULATED PIPELIENS

№	Location of pipeline	Pipelines length, m	Pipeline diameter, m	Surface temperature ,°C	Heat losses, kW
Hot Water Supply					
1	direct line	20	0 089	70	3 5
2	return line	30	0 089	52	2 8
Heating Boiler					
1	--	15	0 600	110	33 0
2	--	20	0 280	110	29 6
3	--	20	0 112	110	10 6
Network pumps					
1	--	5	0 219	60	1 9
2		24	0 520	60	17 4
3	--	18	0 300	60	9 9
4	--	7	0 300	110	10 5
Feed Water Loop					
1	--	16	0 159	100	13 6
2	--	40	0 100	100	16 7
3	--	11	0 089	100	4 1
Condensate Return Line					
1	--	23	0 112	130	14 0
2	--	15	0 159	130	13 5
Steam Pipeline					
1	--	14	0 250	162	25 2
TOTAL, boiler house					**206 3**
Pressing Shop					
1	--	60	0 050	160	28 8
2	--	36	0 062	160	18 7
3	--	108	0 089	160	75 6
TOTAL					**329 4**

APPENDIX IX TESTS OF BOILER №3

Parameters	Unit	Test No	
		1	**2**
Test date		6 July	6-July
Test time	hour min	11-00	11-45
Steam production acc to the meter	t/hour	10	10
Pressure	kg f/cm2	10 03	10 03
Boiler burners			
Gas pressure at the1st burner	kg f/m^2	1200	1200
Gas pressure at the2nd burner	kg f/m^2	1200	1200
Air pressure at the1st burner	kg f/m^2	38	38
Air pressure at the2nd burner	kg f/m^2	38	38
Vacuum in the boiler	mm water	2 5 - 3	1 5 - 2
Effluent gases after the boiler			
Temperature	°C	350	337
Oxygen, O2	%	8 6	7 9
CO2	%	6 9	7 4
Excess air	%	67	53
NOx	ppm	54	52
CO	ppm	0	3
Losses/incomplete burning CO	MCal/h	0	0
Losses/incomplete burning CO	%	0	0
Boiler Efficiency, acc to Meter	%	81 1	83 0
Feed water			
Temperature before economizer	°C	102	102
Temperature after economizer	°C	126	126
Effluent gases after economizer			
Temperature	C	129	124
Oxygen, O2	%	10 7	9 2
CO2	%	5 8	6 5
Excess air	%	95	71
Heat losses with effluent gases	%	8 7	7 3
NOx	ppm	43	43
CO	ppm	3	3
Losses/incomplete burning CO	MCal/h	0	0
Losses/incomplete burning CO	%	0	0
Losses into ambient environment	%	3	3
Boiler Efficiency, acc to Meters	%	93 5	94 4
Design boiler efficiency	%	88 3	89 7

APPENDIX X ANALYSIS OF PROJECT №10 ACCORDING TO THE NET PRESENT VALUE METHOD

Project analysis	Installation of a steam-condensation turbine					
Basic variant						
Discount rate, %	10					
Calculations are made in $US						
Years	0	1	2	3	4	5
Investments	2000000					
Electric power sales		3265000	3265000	3265000	3265000	3265000
Gas costs		-2104400	-2104400	-2104400	-2104400	-2104400
Other expenditures		-23800	-23800	-23800	-23800	-23800
Depreciation deductions		-200000	-200000	-200000	-200000	-200000
Profit before taxes		936800,0	936800,0	936800,0	936800,0	936800,0
Profit tax (35%)		-327880,0	-327880,0	-327880,0	-327880,0	-327880,0
Profit after taxes		608920,0	608920,0	608920,0	608920,0	608920,0
Net cash flow		808920,0	808920,0	808920,0	808920,0	808920,0
Discounting factor		0,909090909	0,82644628	0,751314801	0,68301346	0,620921323
Discounted cash flow		735381,8	668528,9	607753,6	552503,2	502275,7
Payback period		3				
Net present value		-1264618,2	-596089,3	11664,3	564167,6	1066443,2
Internal return rate (5 years), %		29				

Analysis of the sensitivity of project №10 (Internal return rate changes versus electricity sales revenues and in the event of deviations from the expected amount of investments)

Electric power sales	Investmetns				
	-10%	0	+10%	+20%	+30%
0%	35	29	24	20	17
-10%	20	15	11	8	5
-20%	2	--	--	--	--