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Delivery order #30
Energy Efficiency in the industry of Ukraine
April 1998

REPORT

ENERGY AUDIT

AT CLOSED-TYPE JOINT STOCK COMPANY

"FANPLIT"

CITY OF KIEV, UKRAINE

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PREFACE

The work described in this report ha sbeen carried out by Burns and Roe Enterprises, Inc within the framework of the US Agency for International Development (USAID) Contract No CCN-0002-Q-00-3154-00, Delivery Order No 30, Industrial Energy Efficiency - Ukraine

The Ukraine Industrial Energy Efficiency program aims at achieving rapid energy savings from deployment of low-cost energy efficiency equipment and improved energy management at selected industries It also aims at creating the conditions for sustainable energy efficiency practices throughout Ukraine's industrial sector, serviced by private sector engineering services This will be met by establishing local technical capability as well as exposing Ukrainians to U S practices and energy efficiency technologies

1 EXECUTIVE SUMMARY

1 1 Introduction

This energy audit has been conducted under a program sponsored by the US Agency for International Development This project, also referred to as Delivery Order #30, consisted of performing twenty four audits throughout Ukraine The purpose of the project is to develop Ukrainian energy service company (ESCO) capabilities To accomplish this task, Burns and Roe Enterprises, Inc (the primary contractor) hired Ukrainian engineers These engineers were trained in U S techniques of conducting energy audits and in ESCO concepts The industrial energy audits were conducted to facilitate the ESCO training

Since these enterprises are very large, a one week visit is not sufficient to adequately audit the entire facility The site visit was restricted to one week due to project considerations However, the engineering staff were trained to identify improvements that would be representative of the entire plant In many cases it was necessary to focus the auditing efforts on one system or only on a portion of the plant Therefore, this audit is based on what could be accomplished during one week While this audit contains numerous recommendations for the plant management, the plant management is encouraged to perform a complete audit of the entire facility Hopefully, the plant management will consider engaging the engineers trained under this project to continue this work This will result in a complete understanding of energy usage within the plant, as well as a complete listing of all potential energy improvement projects

The current report describes the findings of the energy efficiency audit performed by Burns and Roe at the JSC FANPLIT The FANPLIT plant specializes in production of plywood and wood fiber boards and consumer goods The plant is equipped with Finnish production lines for peeling, chipping and stacking of veneer and a German "Bizon" automatic line

The plant output is in demand locally and in CIS and foreign countries It meets the highest quality standards The production output at 1997 prices amounted to US$5,270,000 The share of energy in the production cost was 18%

The purposes of the energy audit were as follows

- to conduct informal training in the energy management practices
- to create an institutional awareness of energy management
- to recommend specific steps to improve energy efficiency
- to recommend medium-cost capital investments and actions reflecting large-scale energy conservation opportunities

The energy audit team consisting of three Ukrainian specialists performed the energy audit from April 20 through April 25, 1998 In accordance with the Project objectives, the energy audit team prepared the following preliminary report

1 2 Conclusions

The FANPLIT is an energy-intensive enterprise Consumption of energy in 1997 was as follows

- Electric power - 7,530,000 kWh
- Natural gas - 2,530,000 m^3
- Purchased fuel - 12,740 Gcal

The energy audit team has discovered many attractive opportunities of improving energy efficiency at the current energy and fuel prices Today energy efficiency improvements make sense but are difficult to accomplish due to exorbitant interest rates and general economic difficulties

The FANPLIT plant is reasonably successful by Ukrainian standards and is capable of implementing energy savings measures

The existing energy metering system does not analyze energy use efficiency

The project envisages further implementation of long-term measures by the plants themselves in consort with private Ukrainian One of tasks of ESCO development is the capability of acquiring long-term (for 2-3 years) financing for implementation of energy conservation measures at the enterprises

The energy audit team saw a realistic opportunity to render considerable assistance in energy use reduction by introduction of energy management service and other ECOs at the plant under an individual contract after completion of the USAID project

Implementation of the measures proposed in this project will reduce energy consumption and respective costs by 20%

Schedule of this project will make the monitoring phase impossible for ECOs that require heating season for their implementation

1 3 Recommendations

Below is the list of energy conservation opportunities at the plant These measures are recommended to be implemented in the shortest period The plant management is recommended to consider implementation of other ECOs as soon as financially possible

In order to encourage the facility to implement energy efficiency and energy conservation, USAID is contributing energy auditing equipment to the plant This equipment consists of standard energy auditing instrumentation and meters that will implement an energy saving activity
For example, ECO #1 "Institution of energy management" will set up systematic energy conservation activities by establishing an energy management section responsible for the control and analysis of the energy consumption at the plant and development of recommendations for renovation and improvement of any energy saving systems

Generally the energy management section should consist as a minimum of three persons technical supervisor, electrical and thermal engineers The supervisor should be a part of the plant management and report directly to the plant general manager It is essential as energy consumption and energy costs acquire a special importance and a plant manager should be aware of energy conservation potential

The best part of the proposed measures have direct applications with minor adjustments at other industrial plants i e they can serve as a standardized solution for a standard problem

If implemented the measures proposed by the auditors will reduce energy consumption annually

- of electric power by 753,000 kWh (43%)
- of natural gas by 554,000 m3 (21%)
- of thermal energy by 2,027 Gcal (16%),

and will result additionally in reduction of pollutant emissions

1 Solid particles by 14 4 tons/year
2 Sulfur dioxide 32 4 tons/year
3 Carbon oxide by 6 4 tons/year
4 Nitrogen oxide by 8 8 tons/year

Plant energy efficiency can be improved, costs reduced and enhance competitiveness of the enterprise preserved based on recommendations listed in the following Table No 1 The Table lists several energy conservation opportunities with short payback periods

Capital investments of $728,510 into the improvement of energy efficiency (ECO#1 through ECO#8) will result in annual savings of $415,000 later

Energy conservation opportunity (ECO) list

ECO #	Description	Electricity, 1,000 kWh –	Natural gas, 1,000 m^3	Thermal energy, Gcal	Annual savings, $	Project cost, $	Payback, years
1	**Institution of energy management** This ECO will ensure energy use management and reduce energy costs by 10%	753	253	1'274	89'400	44'700	0 5
2	**Comprehensive energy metering system** This ECO will monitor on-line energy consumption, prevent excessive energy use and improve energy efficiency at the enterprise	376	126		28'000	35'000	1 3
3	**Optimization of thermal and ecological parameters of gas firing equipment** This ECO will improve the gas-firing equipment efficiency		50		4'200	6'000	1 4
4	**Thermal insulation of surfaces with temperatures of over 60°C** This ECO will reduce heat losses at non-insulated surfaces and cut down thermal energy costs			185	4'900	1'010	0 2
5	**Energy efficient lighting** Implementation of this project will reduce lighting costs resulting from replacement of mercury lamps with high-pressure sodium lamps	112			5'100	7'800	1 5
6	**Optimization of the refiner main drive operation of the BIZON**	1'800			82'000	190'000	2 3

	equipment of fiber board unit This ECO will reduce electricity costs by introduction of variable speed drive and electric motor efficiency						
7	**Plywood unit dryer oven upgrading** This recommends dismantling of the entire gas generating plant and its replacement with 3 MW VGS-type gas-to-air heaters For supply and recirculation of the drying agent one induced-draught fan should be used instead of two	238	125		21'400	24'000	1 1
8	**Decentralization of thermal energy supply** This recommends two modular automatic boiler units near the plywood workshop and BIZON workshop in order to reduce thermal energy costs			600	180'000	420'000	2 3
	TOTAL	3'279	554	2'059	415'000	728'510	1 8

2 GENERAL BACKGROUND

Chairman of the board of directors Palladiy N Gorbatyuk
Chief power manager Anatoly V Babitzky
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1, Fanernaya str Kiev UKRAINE 252160

2 1 Enterprise history

The closed-type joint-stock company "Plywood and boards" (former plywood plant) was established in 1908 by the Goebel brothers of German descent The plant was a part of a sugar refining company and was founded for plywood production for packing During the Civil and Second world wars the plant was twice destroyed and rebuilt in 1950 The plant employed around 500 at that time and plywood output was 15,000 m^2 annually

In 1960s the plywood production line was renovated and scaleboard plywood production expanded The maximum output of 27,000 m^2 was reached in 1988

During the Soviet Union era in 1986 the plant for the first time started production of wood fiber boards by dry pressing Calendar technology at the automatic line and equipment of the German Bizon company manufacture with capacity of 10,5 mln m^2 annually

The plant comprises three main production units, several auxiliary service workshops

The main production units are as follows
- plywood workshop for production of plywood boards, scaled components for chairs, children chairs, peeled veneer, consumer goods from in-plant materials and waste,
- wood fiber board workshop for various thicknesses and sizes,
- plywood and board laser processing unit for art wares,
- raw material warehouse where plywood raw materials are accepted, sorted by sizes and delivered for processing and lumber wastes are processed for fiber board production

The auxiliary units are as follows
- mechanical and energy,
- mechanical repair,
- motor transport,
- technical materials warehouse

Currently all workshops and units operate, there are four railroad tracks and paved motor roads

The primary energy consumers are as follows
- wood fiber board workshop uses 65% of steam, 87% of electric power and 74 7% of gas out of total annual consumption,
- plywood workshop consumes 31 3% of steam, 10% of electric power and 25 3% of gas

The wear of the equipment is 86%

2 2 Plant products

Production output in 1997 was
- scaleboard plywood - 4,546 m^3,
- wood fiber board - 5,775 8 thousand reference m^2

Total production output at current prices was 9,748 thousand hrivnas

The products are of high quality, meet state standards and technical requirements

2 3 Number of employees

The FANPLIT complex has been a 100% private company since 1998

The closed-type joint stock company presently employs 470 including
production personnel - 456,
including workers - 375

Among the plant specialists there are representatives of two schools - the Moscow and Lviv institutes This fact characterizes high creative potential of the engineering staff

2 4 Number of similar enterprises in Ukraine

Currently there are six plants manufacturing similar products in Ukraine
1 Vygoda wood product complex (wet fiber board production)
2 Cherkassy wood processing complex (plywood, veneer)
3 Lviv plywood works (plywood, peeled veneer)
4 Krasnoilsk wood processing complex (plywood)
5 Uzhgorod plywood and furniture complex (plywood)
6 Orzhev wood processing complex (plywood)

2 5 Significance of the sector for the economy of the country

The FANPLIT products are widely used in construction, railroad car manufacturing, automobile industry, packaging and furniture production and for repairs

In 1997 Ukraine produced

• plywood	25,500 m^3
including FANPLIT	4,546 m^3 (17 8%),
• wood fiber boards	12,750,000 reference m^2
including FANPLIT	5,775,800 reference m^2 (45 3%)

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3 CURRENT STATUS OF PRODUCTION

3 1 Gross output

Production output over the last three years was as follows

1995	- 7,403 Hr
1996	- 8,601 Hr
1997	- 9,748 Hr

Production output in 1997 as compared to 1995 grew by 32%

3 2 Productivity of labor 1997 vs 1996

Productivity of labor in 1997 was 21,199 Hr per employee and grew by 27 4% as compared to 1996

3 3 Development prospects

The JSC FANPLIT operated using raw materials from Russia Since the demise of USSR raw material supplies from Russia has ceased that resulted in a sharp drop of production output plywood - sevenfold, fiber boards by 1 9 times Over the last 5 years the plant managed to go into raw material markets of Ukraine and over the previous three years the plywood and fiber board production decrease stopped Currently all production units of the complex operate

The complex has a stable operation and financial status though the lack of turnover funds impedes solution of the issues of renovation, introduction of new lines and technologies

The lack of turnover funds for the purchases of raw and auxiliary materials forces the plant to process outside-owned materials and set product selling prices for domestic market lower than those of for the products of competing plants

The FANPLIT company is cooperating with the British woodworking federation that is proven by the appropriate certificate The company works consistently at the sales issues, widely advertises it via the Ukrainian mass media and Internet resulting in new customers both at home and abroad

3 4 Exports vs Domestic sales

During the Perestroika period exports have dropped sharply since in the Soviet Union exportation was carried out by the USSR Exportles Under those conditions the plant had no access to foreign markets

Over the last six years the plant has exerted maximum effort to study foreign markets, plywood and fiber board prices and quality requirements abroad This resulted in the following export figures over the previous three years

Share of exports in total sales

#	Description	Unit of measure	1995	1996	1997
1	Scaleboard plywood	%	9 9	26 2	6 1
2	Wood fiber boards	%	21 6	12 2	9 8

The products are sold at the Eurasian and American markets The main partners are Britain, Germany, USA, Poland and other countries In 1998 contracts were made with Egypt and Turkey

4 FINANCIAL STATUS OF ENTERPRISE

4 1 Currency vs Barter ratio

Links with suppliers are stable though it is not always possible to pay with money and the company is compelled to barter for material supplies

Due to turnover fund limitations the receivables are partially covered by barter operations In 1997 barter constituted 30% (2,884 thousand hrivnas) out of total sales (9,623 thousand hrivnas)

The barter operations is a forced measure for enterprise survival under the existing tax and credit conditions Improvement or deterioration of the situation depend on the current legislation of Ukraine

4 2 Viability of the enterprise

The financial situation of the plant can be Called stable There are no wage or budget arrears The company is paying dividends on the shares on a regular basis

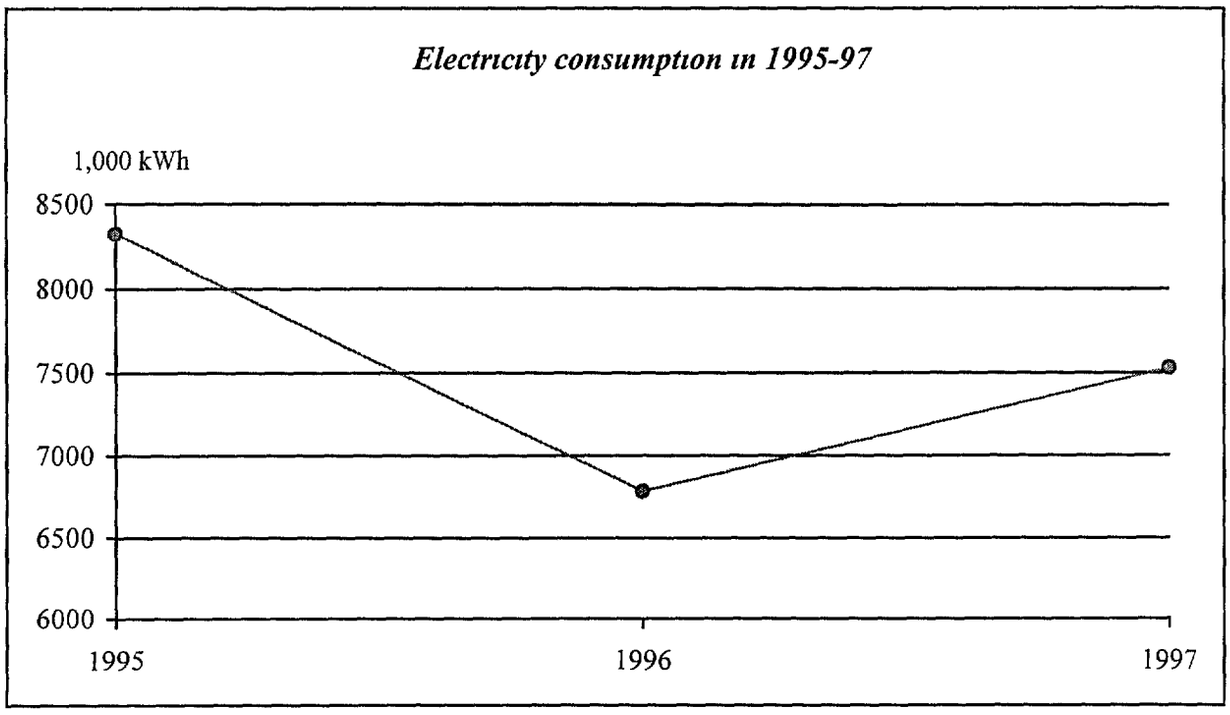
Due to the lack of turnover funds their replenishment by acceleration of turnover the enterprise has a low profitability The profitability in 1997 was

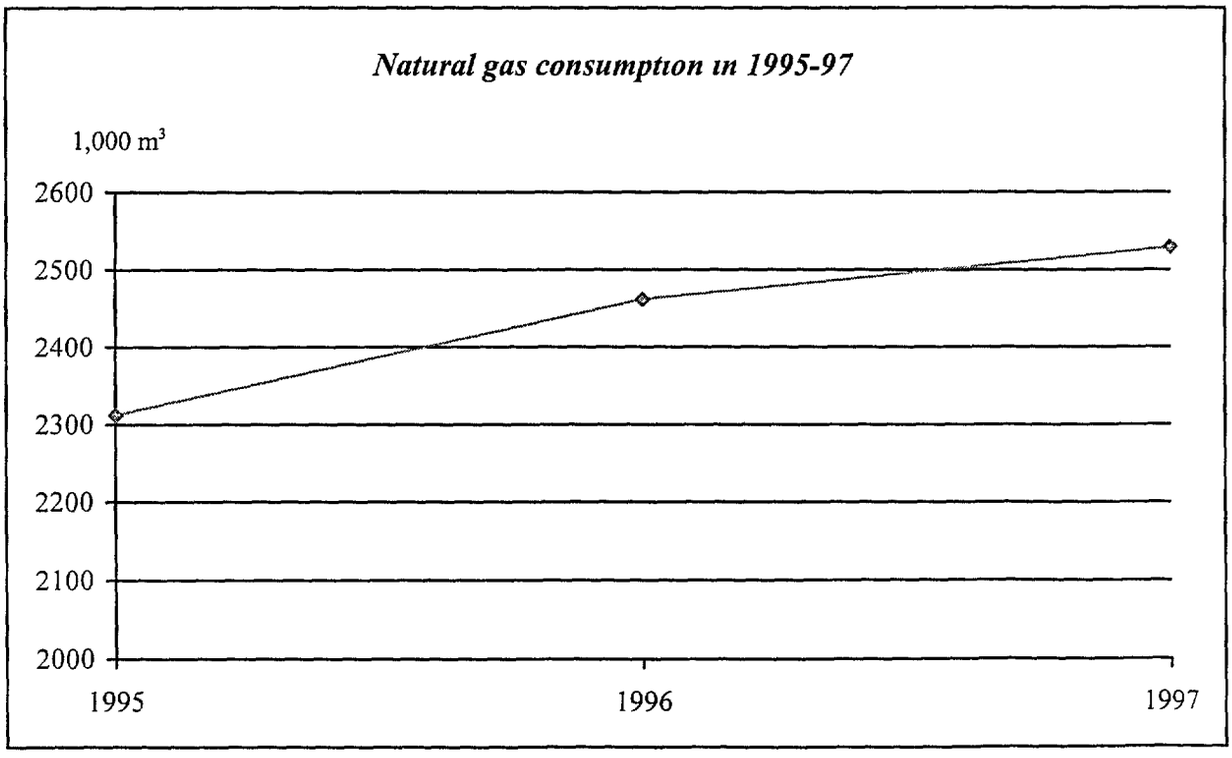
- of production output - 12 7%
- of production sales - 14%

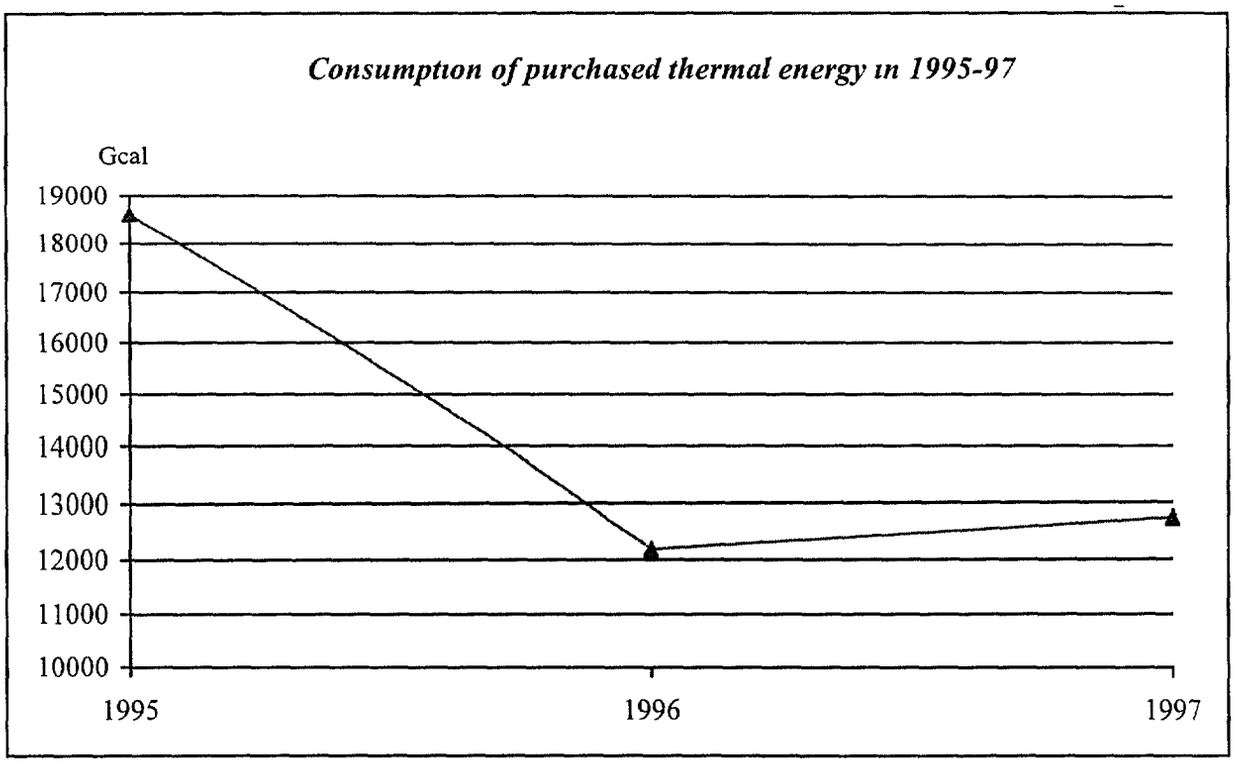
The share of energy in the production cost is 18%
Receivables in 1997 were 613 thousand hrivnas
Payables were 1,480 thousand hrivnas

5 ANNUAL ENERGY CONSUMPTION AND COSTS

5 1 Annual energy consumption in 1997







The analyses of the energy consumption charts of the FANPLIT plant over 1995-97 show that in 1996 there was a drop in production as compared to 1995

Increase of natural gas consumption in 1996 and 1997 was conditioned by obsolescence of gas firing equipment of the plywood workshop and absence of the in-plant energy management

Breakdown of energy consumption and costs in 1997

#	Type of energy	Unit of measure	Consumption	Cost, thousand US$
1	Electricity	MWh	7,530	350
2	Thermal energy (purchased)	Gcal	12 740	348
3	Natural gas	1,000 m^3	2,630	210
	TOTAL			908

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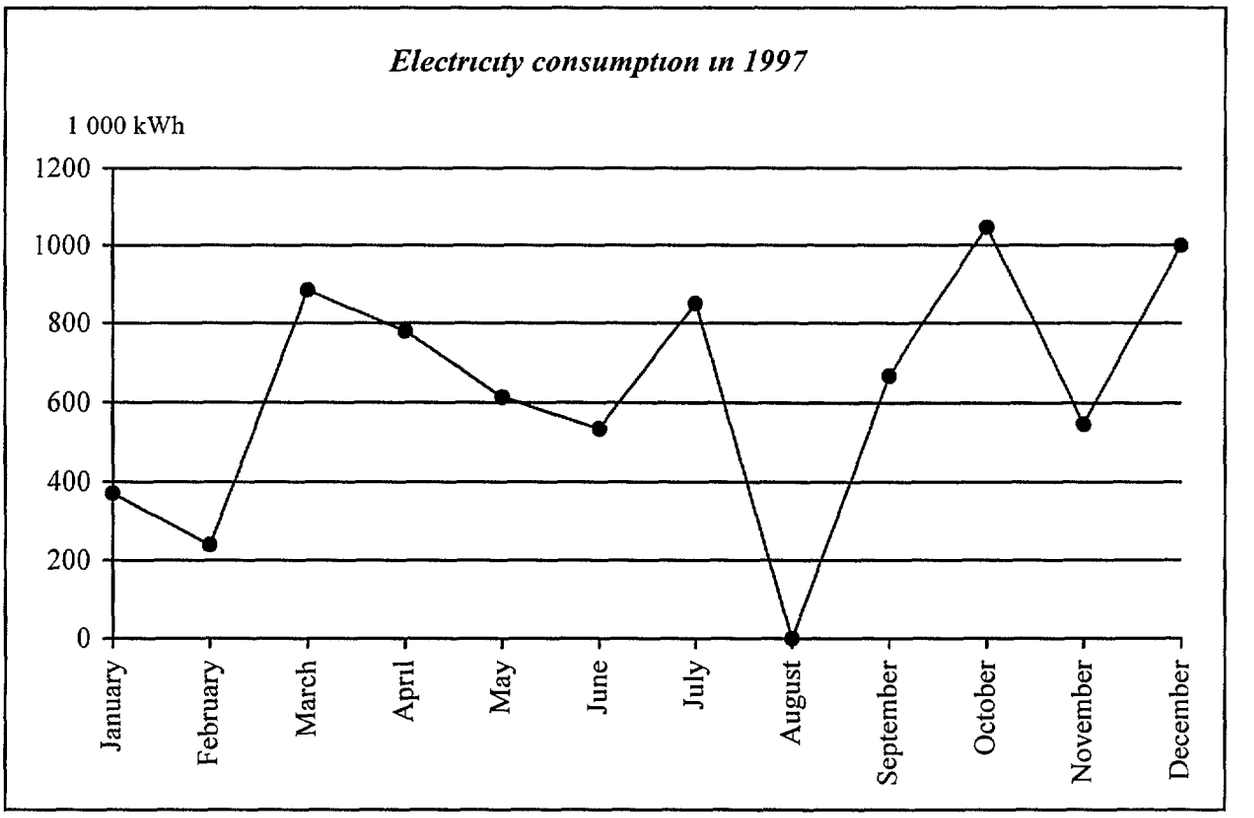
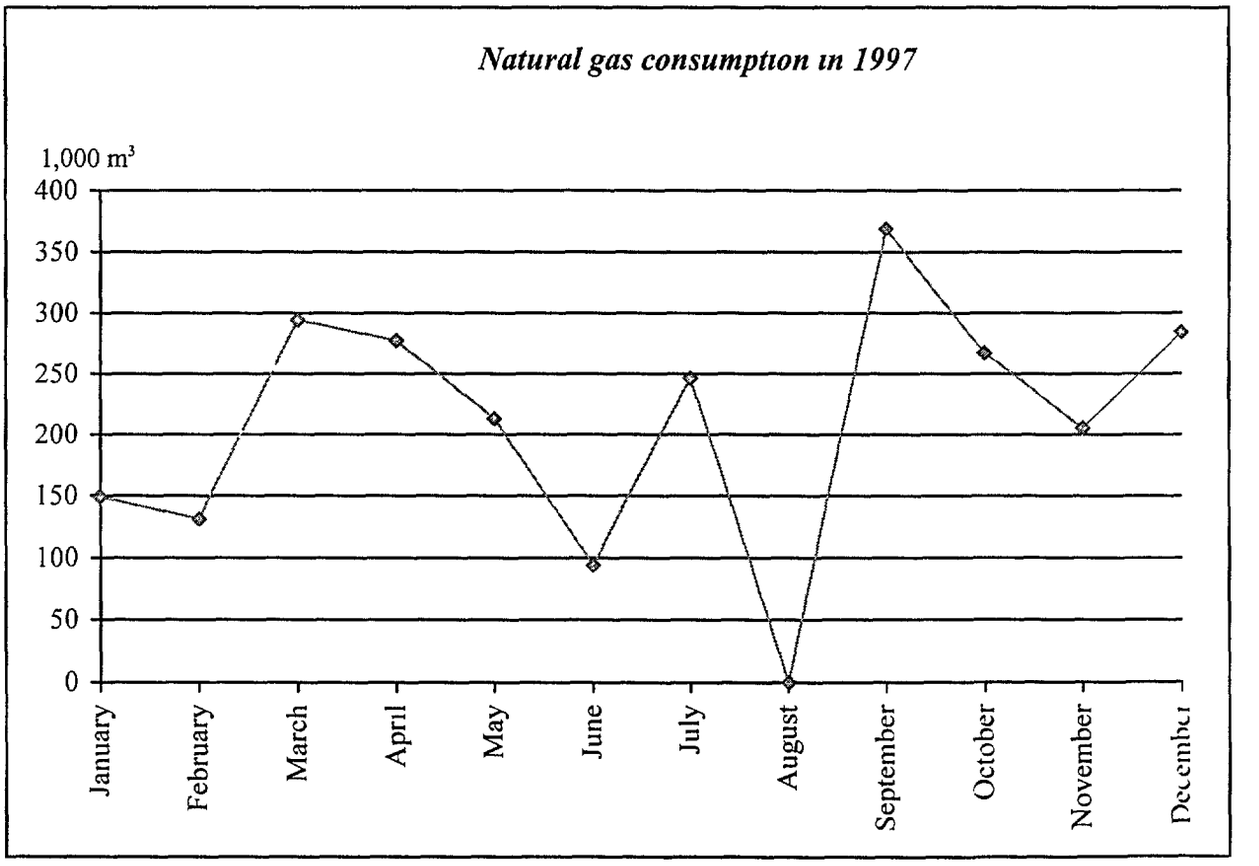

Electricity consumption in 1997
1 000 kWh
1200
1000
800
600
400
200
0
January
February
March
April
May
June
July
August
September
October
November
December


Natural gas consumption in 1997
1,000 m³
400
350
300
250
200
150
100
50
0
January
February
March
April
May
June
July
August
September
October
November
December

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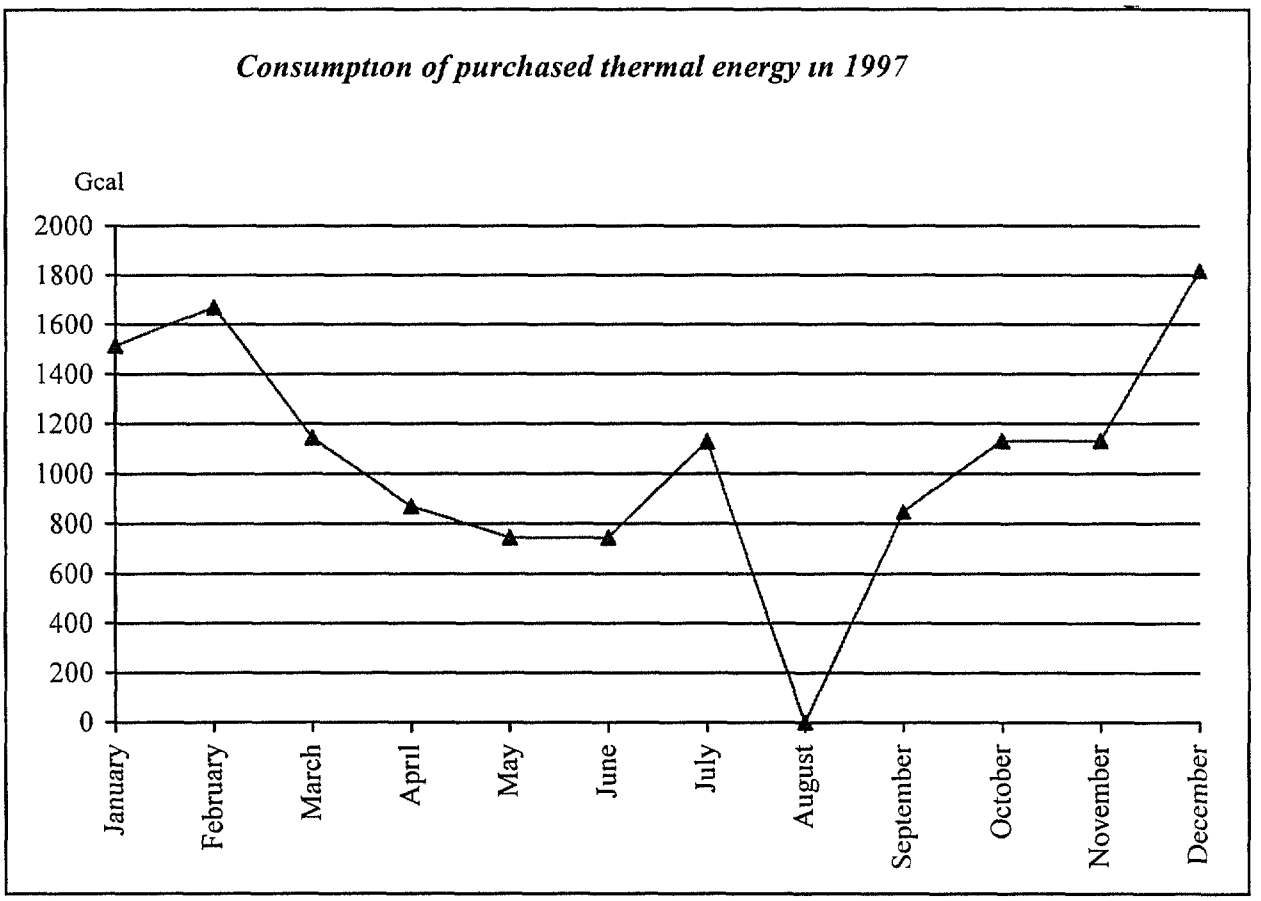

One can arrive at the conclusion from analyzing the 1997 energy consumption charts that thermal energy use corresponds to the seasons and workloads

Electricity consumption depends on the workload cycles, however, in October there was an evident overuse of electricity

Gas consumption in general matches the workload but due to the obsolescence of gas firing equipment of the plywood workshop there was an evident overuse of natural gas in September after the vacation season in August when the plant was completely idle

5 2 Current energy and fuel prices

Electricity

Average for 1 kWh by the plant data is $0 046

Fuel

The sole type of fuel used by the enterprise is natural gas
The cost of 1000 m^3 is $83

Thermal energy

The complex purchases steam heating and production purposes from via main pipeline from thermal energy power plant No4
The cost of 1 Gcal is $26 5

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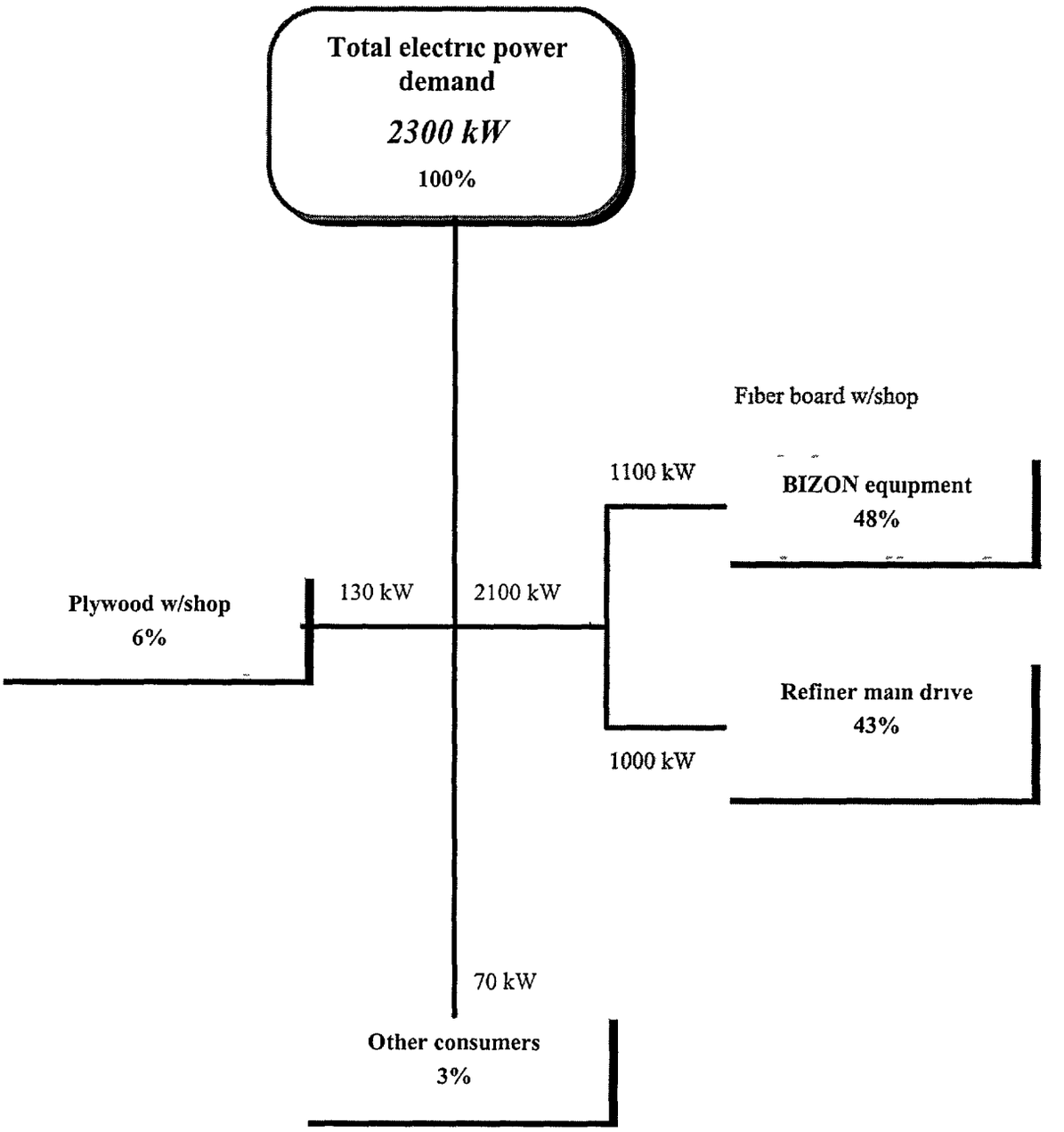
5 3 Energy use profile

Average daily electricity balance of the FANPLIT plant on April 3,1998



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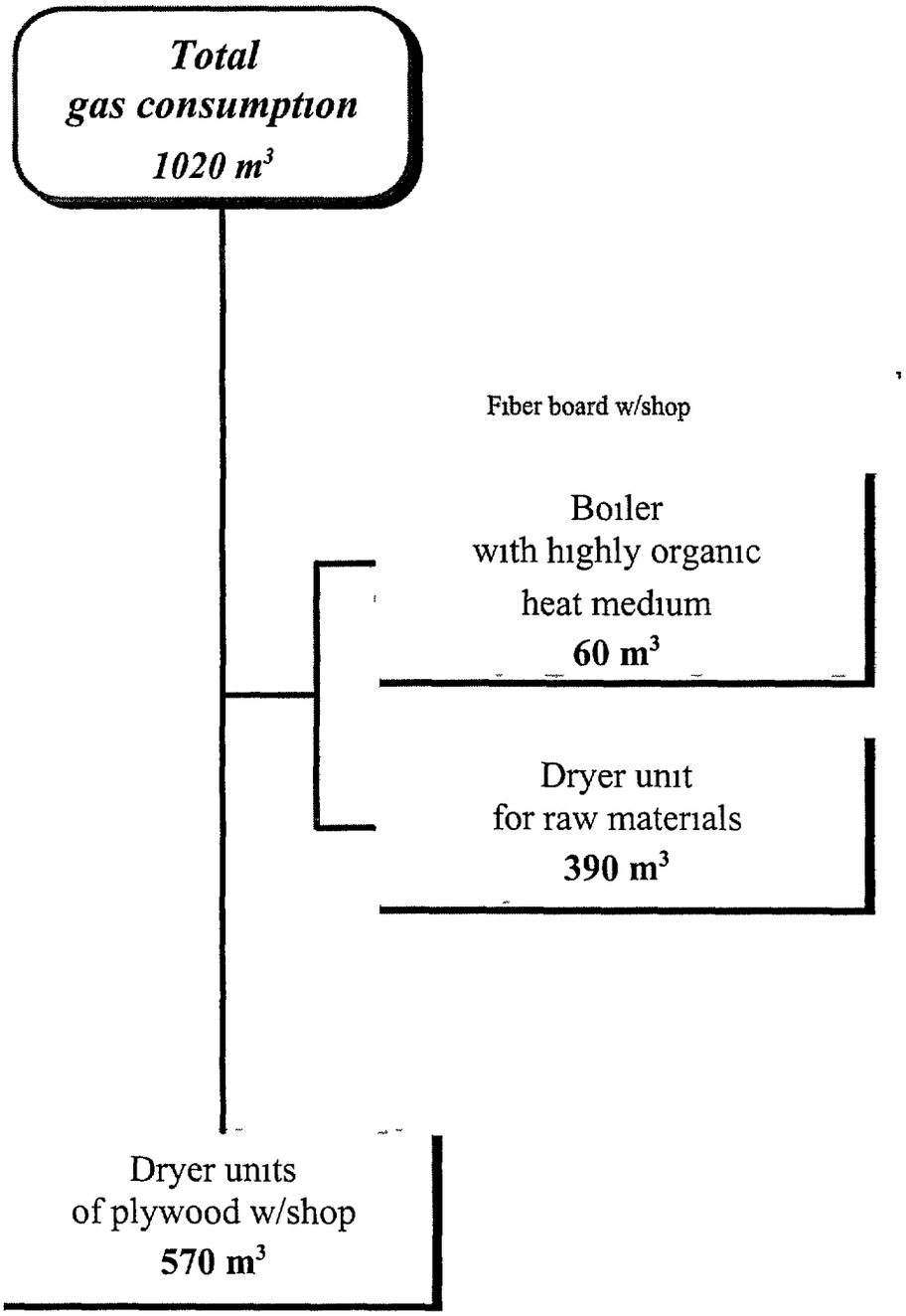
Average hourly gas consumption of the FANPLIT plant



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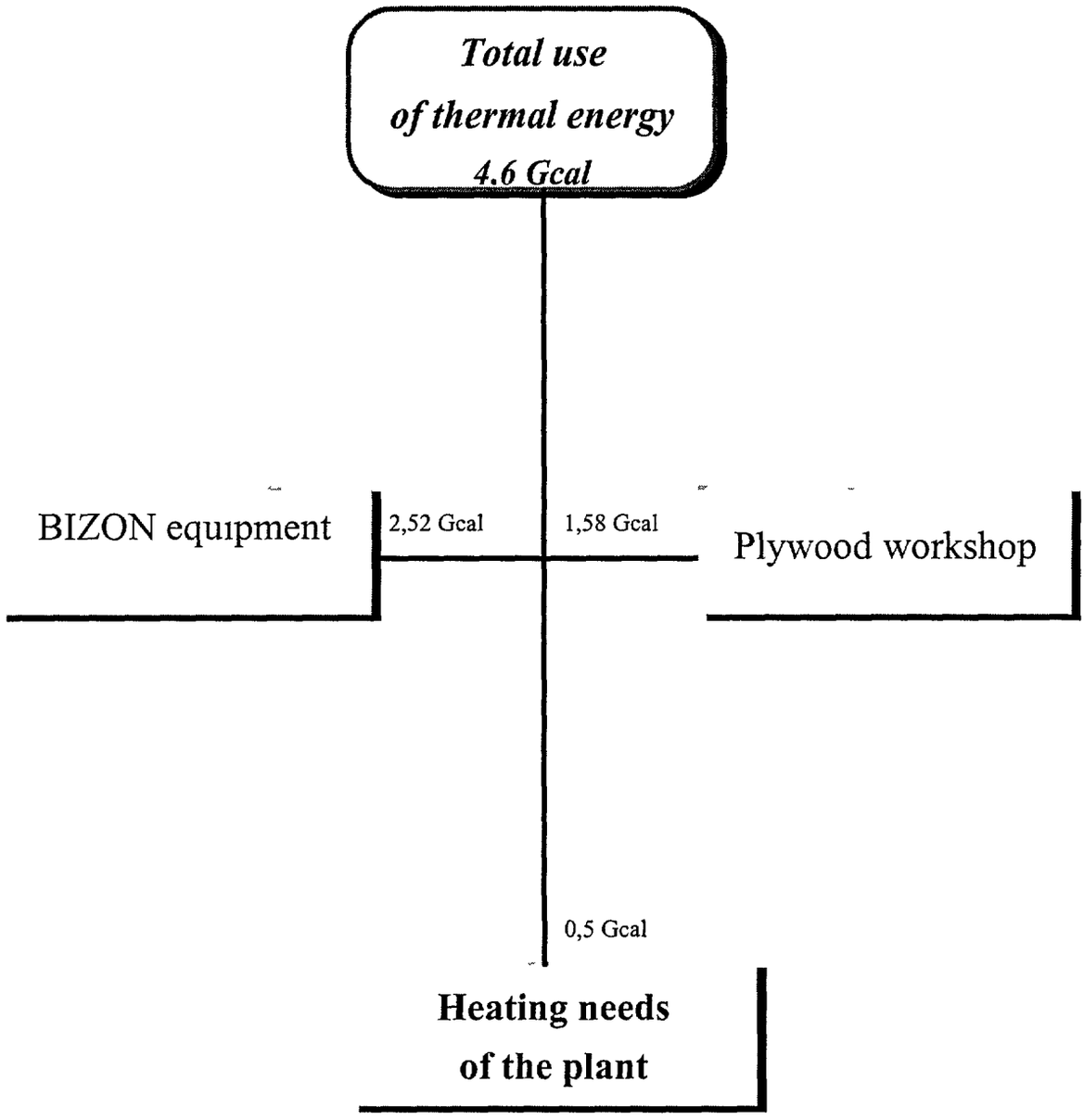
Thermal energy use balance
of the FANPLIT plant



6 PREVIOUS IMPROVEMENTS IN ENERGY EFFICIENCY

The following are energy conservation measures implemented in 1998 by the FANPLIT plant

1 Optimization of SRG-25 roller drying oven design (replacement of gas burners)
2 Development of a new gas burner with lower gas consumption in the dryer duct of No2 workshop
3 Development of conversion design for improvement of gas meter accuracy from 1 5 to 1
4 Introduction of automatic control of reactive power compensation at the plant
5 Introduction of automatic control of reactive component of the 10kV asynchronous electric motor of 1,600 kW capacity
6 Purchase and installation of steam boilers of 6 tons/hr capacity

The chief power manager section each year drafts energy conservation measures Low capital-intensive measures are implemented by both chief power manager section and plant inventors However, capital-intensive measures remain unimplemented

7 ENERGY AUDIT

As the result of the energy audit at the OJSC FANPLIT the audit team recommended several proposals for improvement of energy efficiency at the plant The majority of the problems are typical for Ukrainian enterprises so the solutions of these problems can be replicated for enterprises with similar systems of energy use

Introduction of the recommended measures will reduce annual energy consumption

1	Electricity	by 3,279,000 kWh (43%)
2	Natural gas	by 554,000 m^3 (21%)
3	Thermal energy	by 2,059 Gcal (16%)

The results of technical and economic calculations of energy conservation opportunities are given below

ECO #1 - Institution of energy management

Energy management is the main avenue by which energy usage reduction and increase in consumption efficiency can be achieved Energy management is a management system based on standard measurements and checks providing for such operation of the plant that ensures only absolutely necessary consumption of energy for production purposes

In order to implement continuous supervision and analysis of energy use we recommend to institute energy management system and provide necessary measuring equipment

Implementation of this project will reduce fuel and energy costs by 89,400 $/year Payback period will be 0 5 year
See details of this proposal in Appendix A1, ECO #1

ECO #2 -Comprehensive energy metering system

In order to implement energy management and introduction of cost-accounting within the works production units it is necessary to upgrade the existing energy metering system As one of upgrading options we recommend the ITEK technical instrument set which possesses metrological characteristics and is designed for continuous and periodical (express analysis) measurement/registration of physical values

Introduction of the ITEK-X1X allows consumers to pay their electric power bills by the one-rate tariff differentiated according to the daytime zone which in conjunction with the measures of reduction of the maximum hour consumption provides a considerable cost effect that has been proven by more than annual operation at numerous Ukrainian facilities

ITEK-220 and ITEK-320 are designed for automatic commercial metering and telemetric control of supply and consumption of liquids, gases, steam and thermal energy in combination with any primary measurement converters of consumption, temperature, pressure and pressure drop with standardized output parameters at supplier's (thermal power plant, district heat, boiler houses) and consumer's sites (industrial enterprises, public utility facilities)

Implementation of this project will reduce fuel and energy costs by 28,000 $/year Payback period will be 1 3 years

See details of this proposal in Appendix A2, ECO #2

ECO #3 - Optimization of thermal and ecological parameters of gas firing equipment

Currently the plant uses two dryer units and a boiler with highly organic heat medium The energy auditors took measurements of combustion gas composition with the ENERAC-2000 combustion analyzer Only at the BIZON dryer the gas analysis was satisfactory At the boiler with highly organic heat medium the burner unit operated with large air excess At the veneer dryers the lower burners were fired with resulting incomplete burning

The energy auditors think it necessary to optimize the operation of gas firing equipment in terms of both Ecological and thermal parameters and catty out consistent supervision over gas combustion modes For this purpose it is suggested to utilize the ENERAC-2000 combustion analyzer

Implementation of this project will reduce fuel and energy costs by 4,200 $/year Payback period will be 1 4 years
See details of this proposal in Appendix A3, ECO #3

ECO #4 Thermal insulation of surfaces with temperatures of over 60^{0}C

The results of the steam distribution system analysis showed that some steam pipelines do not have thermal insulation Energy losses due to the lack of insulation are enormous Temperature inside work rooms reaches 40^{0}C at the ambient temperature of 5^{0}C that impairs working conditions

We recommend that the steam piping should be fully insulated The thickness of insulation should be selected dependent on the piping diameter and its purpose

Implementation of this project will reduce fuel and energy costs by 4,900 $/year Payback period will be 0 2 year
See details of this proposal in Appendix A4, ECO #4

ECO #5 Energy efficient lighting

The external lighting system of the plant area consists of lighting fixtures with 45 DRL - 250 high pressure mercury lamps The production buildings are lighted by 75 DRL - 400 high pressure mercury lamps The light flow of the DRL-400 lamp is equal to 23,000 lumen and service life is 6,000 hours, DRL-250 - 10,000 lumen and 2,400 hours, respectively

It is suggested to consider the proposal of replacement of DRL -250 high pressure mercury lamps for external lighting of the plant area and internal lighting with the DNaT-100-3 high pressure sodium lamps using existing fixtures and replacing switching appliances We recommend to replace the DRL -250 high pressure mercury lamps for internal lighting with the DNaT-100-3 high pressure sodium lamps using existing fixtures and replacing switching appliances

Implementation of this project will reduce fuel and energy costs by 5,100 $/year Payback period will be 1 5 year
See details of this proposal in Appendix A5, ECO #5

ECO #6 Optimization of the refiner main drive operation of the BIZON equipment of fiber board unit

In the overall electricity use balance the electric motor of the refiner main drive comprises 40% of active power load and 85% of reactive power load Currently the main drive operation mode is continuous

By the meter readings in March 1998 average motor load was around 700 kW at average cosϕ = 0 74

In order to reduce power consumption we recommend to introduce variable speed control Utilizing variable speed drive smooth start and stop of the motor will be ensured

Implementation of this project will reduce fuel and energy costs by 82,000 $/year Payback period will be 2 3 year
See details of this proposal in Appendix A6, ECO #6

ECO #7 Plywood unit dryer oven upgrading

For veneer drying in the plywood workshop a roller drying unit is used Exhaust gases are used as the drying agent Currently a primitive plant made up of a combustion chamber with two bottom burners, a chamber for mixing combustion products with air and recirculated drying agent is used for generation of the primary drying agent Supply of the drying agent from the mixing chamber and recirculation of the drying agent are performed by two DN 12,5 fans Each fan is equipped with a 75 kW electric motor While measuring the electric loads it turned out that their loads were 45 kW each

The combustion gas analysis showed the presence of carbon monoxide - 0 03% CO - indicating that with tenfold dilution of combustion products there are considerable losses of energy connected with incomplete combustion

The energy auditors see it expedient to dismantle the entire gas generation unit and replace it with a gas and air heater of the VGS type with 3 mw capacity For supply and recirculation of the drying agent one draught fan should be used, not two

Implementation of this project will reduce fuel and energy costs by 21,400 $/year Payback period will be 1 1 year
See details of this proposal in Appendix A7, ECO #7

ECO #8 Decentralization of thermal energy supply

Currently the plant purchases thermal energy from the Darnitsa power plant The steam is used both for production purposes and space heating The condensate is not returned to the Darnitsa power plant and is used for wood treatment in the plywood workshop

Given the high purchasing price and the prospects of further increase the energy auditors see it expedient to decentralize the thermal energy supply The proposal is to install to modular automatic boilers near the plywood workshop and the BIZON production line respectively of 2 5 and 5 ton capacity In order to ensure flexibility, reliability and cost-efficiency of thermal energy supply the boiler units should incorporate two boilers each

Implementation of this project will reduce fuel and energy costs by 180 000 $/year Payback period will be 2 3 years
See details of this proposal in Appendix A8, ECO #8

8 ENVIRONMENTAL IMPACT OF RECOMMENDATIONS

The most efficient way of reduction of hazardous emissions into the atmosphere is decrease of fuel and electric power use Energy conservation and efficiency are extremely urgent from the Ecological standpoint

The proposed project contains energy conservation measures aimed at saving fuel and electric power The main fuel used at the JSC FANPLIT is natural gas The harmful substance that forms in significant quantity during combustion of this fuel is nitrogen oxide (NO_X) The nitrogen oxides are harmful to the human health and can cause severe respiratory problems
Since combustion of natural gas results in the least emissions of the carbon dioxide CO_2 (that is the main gas responsible for setting "the green house effect"), saving natural gas will contribute to weakening of "the green house effect" Carbon monoxide (CO) is emitted after an incomplete combustion of fuel, it reacts with other substances and has various detrimental impacts Sulfur dioxide resulting from combustion destroys materials

Annual energy resource savings due to implementation of energy management will be as shown in the Table1

1 Electricity saving - 3,279,000 kWh
2 Natural gas saving - 554,000 m^3

According to the data from the Ministry of Energy, in 1996 1 kW h of the electric power meant emitting into the atmosphere of 17 g of contaminating substances, including the following

sulfur dioxide SO_2	9 9 g
carbon oxide CO	0 5 g
nitrogen oxides NO_x	2 2 g
solid particles	4 4 g

Reducing electric consumption results in decreasing the amount of the emitted harmful substances that can be determined by the formula

$$h = h_n \quad E_{ps},$$

where

h_n - the specific content of emissions, g/kW h
E_{ps} - electric power saving, kW h

Amounts of pollutants formed during generation of 6,720,000 kWh

1) sulfur dioxide SO_2	h_1 = 9 9 x 3,279,000= 32,400,000 (g/year)
2) carbon oxide CO	h_2 = 0 5 x 3,279,000 = 1,600,000 (g/year)
3) nitrogen oxides NO_x	h_3 = 2 2 x 3,279,000 = 7,200,000 (g/year)
4) solid particles	h_4 = 4 4 x 3,279,000 = 14,400,000 (g/year)

Calculation of the carbon oxide that forms after combustion of oil-well gas is made by the formula

$$M_{CO} = 0\ 001 \quad B \quad K_{CO} \quad Q_r\ (1 - q/100),$$

where

B - consumption of oil-well gas, m^3/yr
K_{CO} = 0 25 kg/GJ - the quantity of carbon oxide that is produced per heat unit released after combustion of oil-well gas
Q_r = 35 MJ/m^3 - the lowest Calorific value of natural fuel
q = 0 5 % - heat losses resulting from an incomplete gas combustion

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M_{CO} = 0 001 554,000 0 25 35 (1 - 0 5/100) = 4,800 (kg/yr),

or

M_{CO} = 4 8 tons/yr

Calculation of the nitrogen oxides per time unit (t/yr) shall be done by the formula

M_{NOx} = 0 001 B K_{NOx} Q_r (1 - b),

where

K_{NOx} = 0 1 kg/GJ - a parameter characterizing the amount of the nitrogen oxides forming per 1 GJ of heat, kg/GJ,

b = 0 15 - a coefficient for taking into account the degree of decreasing the level of emissions of nitrogen oxides resulting from implementation of technological measures

M_{NOx} = 0 001 554,000 0 1 35 (1 - 0 15) = 1,600 (kg/yr),

or

M_{NOx} = 1 6 t/yr

Implementation at the FANPLIT of energy conservation measures will decrease the energy resource consumption, and in its turn lower the quantity of harmful emissions into the atmosphere

TABLE OF POLLUTANT EMISSION REDUCTION

	Reduction in emissions as result of the energy savings, t/yr		
Emissions	**Electric power**	**Natural gas**	**TOTAL**
Hard particles	14 4	-	14 4
Sulfur dioxide	32 4	-	32 4
Carbon oxide	1 6	4 8	6 4
Nitrogen oxides	7 2	1 6	8 8
Total emission reduction			220 6

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APPENDIX A. ENERGY CONSERVATION OPPORTUNITIES (ECO)

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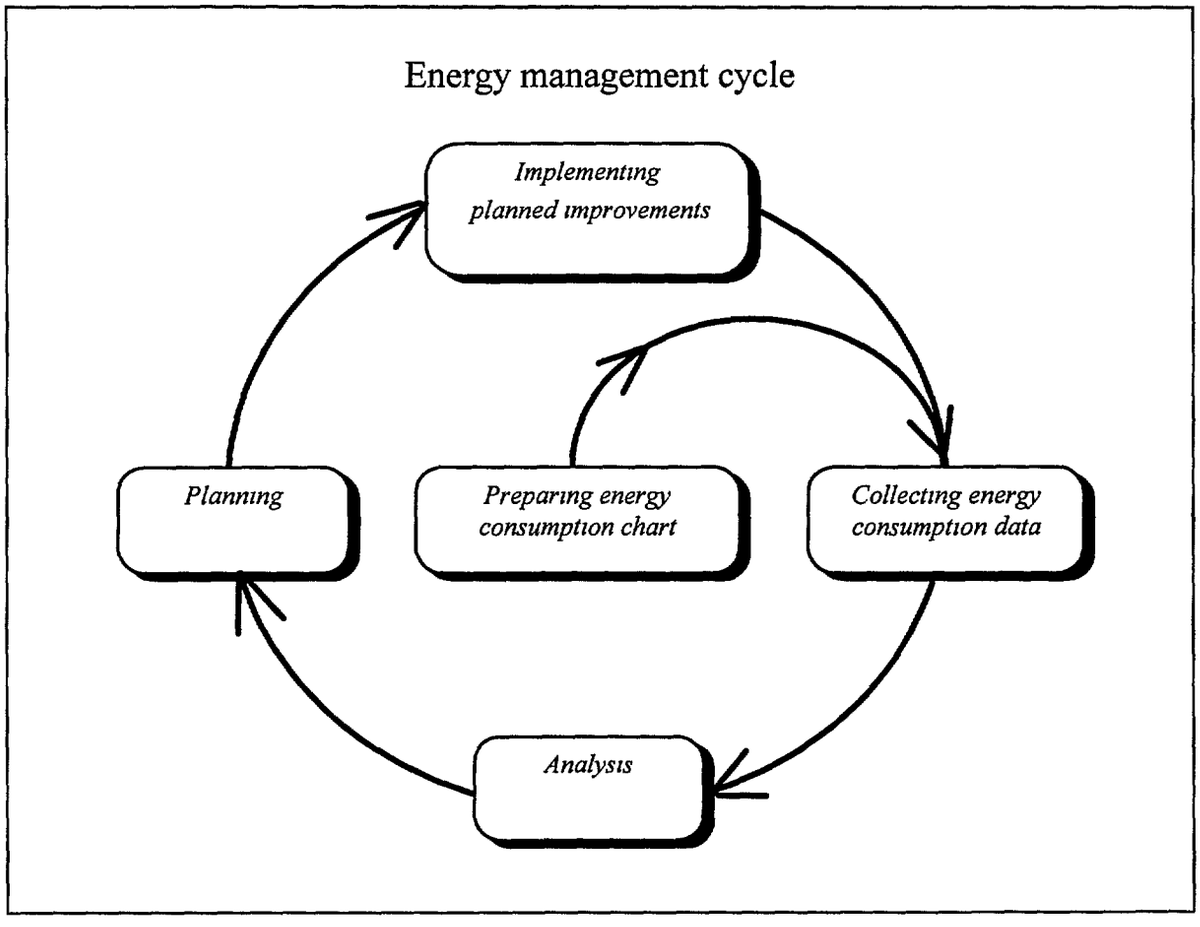
A 1 ECO - 1 Institution of energy management

ECO description

Energy management is the main avenue by which energy usage reduction and increase in consumption efficiency can be achieved This management strategy is based on conventional measurements and documentation and provides operating conditions that facilitate minimal energy consumption needed for the technology This is also a management tool which comprises a continuous research allowing precise knowledge on facility's energy distribution and consumption, as well as on best energy utilization for production, district heat and other non-productive purposes



Implementation of energy management program will result in having more detailed energy consumption records Such system will allow comparison of the energy usage to that of other enterprises for precise evaluation of energy saving projects that are considered by the facility

Implementing an energy management activity typically would involve establishing a separate section of employees to deal only with energy efficiency At a minimum an energy management section should consist of three people technical supervise, an electric engineer and a thermal engineer

The main duties of an energy management section include

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- Preparing facility's energy consumption chart (probably in collaboration with an outside consultant, energy auditor),
- Collecting fuel and energy consumption data using measuring and testing equipment,
- Preparing a plan for implementing additional measuring and testing equipment,
- Collecting data on raw materials and energy consumption and on production output,
- Making key Calculations on improving energy efficiency - for overall facility as well as specific production lines,
- Implementing new technologies on existing and new energy systems to improve energy efficiency of operation,
- Encouraging the personnel to indicate potential energy conservation opportunities
- Keeping informed on current energy policy trends and neighboring issues, (e g , such as new tax legislation, existing consumption restrictions, subsidies, environmental aspects etc)

In order to implement permanent energy consumption monitoring and analysis we recommend to institute energy management system at the plant and to provide required measuring equipment The set of equipment that will be useful for the plant should include

- three phase energy analyzer,
- tachometer,
- hot-wire anemometer,
- combustion analyzer,
- non-contact thermometer,
- ultrasonic leak detector,
- digital contact thermometer,
- light meter,
- power factor meter,
- portable temperature/humidity/ dew point meter,
- computer with printer

Annual energy savings

Currently the works use annually on average 7,530,000 kWh of electric power, 2,530,000 m^3 of natural gas and 12,740 Gcal of thermal energy

Typically, combustion efficiency improves by 2 5% from utilizing the combustion analyzer Electric power use efficiency can be linked to a wide range of factors i g power factor correction, improvement of equipment load control (shutting off idling equipment), optimization of motor loads, optimization of pump operation, improvement of compressor load control, etc On average improvement of electric power use can ensure from 3 to 10% savings of total electric power consumption

The global experience and practice show that in case of institution of full-time energy management ensures 10% of fuel and energy consumption savings Energy savings will amount to

1) Electric power - 7,530,000 x 0 1 = 753,000 (kWh)
2) Thermal energy - 12,740 x 0 1 = 1,274 (Gcal)
3) Natural gas - 2,530,000 x 0 1 = 253,000 (m^3)

Annual cost saving estimate

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1 At the price of $0 046 per 1 kWh of electric power the cost savings will be
753,000 x 0 046 ~ $34,640
2 At the price of $26 5 per 1 Gcal of thermal energy the cost savings will be
1,274 x 26 5 = 33,760
3 At the price of $83 per 1,000 m^3 of natural gas the cost savings will be
253 x 83 ~ $21,000

Total energy cost savings will be
34,640 + 33,760 ~ $89,400

Implementation Costs

According to the world practice, expenses on implementing energy management constitute 50% of estimated energy savings, i e

89,400 x 0 05 ~ $44,700

Simple payback

Implementation costs - $44,700
Annual cost savings - $89,400
Simple payback period will be
44,700/89,400 ~ 0 5 (year)

A2 ECO- 2 Comprehensive energy metering system

ECO description

Energy and fuel consumption monitoring and precise breakdown of this consumption by production lines and units is one of the basic tools of energy management This will provide a realistic depiction of the energy balance of the enterprise, opportunity of energy use assessment and viable possibility of fuel consumption dependent on the equipment characteristics and workloads

Though the existing system of electric power metering permits to acquire a picture of electricity consumption and distribution among production lines, however, it is cumbersome in processing and evaluation of obtained results Thermal energy metering system of the works combines utilization of instrument metering and Calculating without the use of measuring devices which precludes provision of realistic thermal energy consumption registration

In order to implement energy management and introduction of cost-accounting within the works production units it is necessary to upgrade the existing energy metering system As one of upgrading options we recommend the ITEK technical instrument set which possesses metrological characteristics and is designed for continuous and periodical (express analysis) measurement/registration of physical values

Introduction of the ITEK-X1X allows consumers to pay their electric power bills by the one-rate tariff differentiated according to the daytime zone which in conjunction with the measures of reduction of the maximum hour consumption provides a considerable cost effect that has been proven by more than annual operation at numerous Ukrainian facilities

ITEK-210 and ITEK-310 are intended for commercial and technical metering of electric power (differentiated by time) and build-up of automatic metering and control systems of electric power use (AMCSEPU) in combination with electric meters of three-phase induction type equipped with pulse generation devices (E440, E870, UP-1, UP-2, UP-3, SU-500) or electronic (Siemens, Lands and Gyre, Alpha-ABB, etc) with pulse output They support 64 (for ITEK-210) or 12 (for ITEK-310) metering channels, 4 tariff zones, day schedule for all metering channels is a 5 days' minimum, 2 independent data interfaces

ITEK-210 can be used in combination with or instead of the installed TsT-5000 systems by connection to the existing matrix of primary measurement converters The ITEK-210 is included in the State register of measurement devices of Ukraine

The ITEK-410 is designed for 4 metering channels and is similar to the above devices Additionally it supports tariffs differentiated by peak consumption and demand, and provides monitoring and control over consumption process Daily schedules from 4 channels are stored for not less than 1 month

Introduction of ITEK-X2X allows consumers to meter resources with high accuracy and pay the bills for actual consumption but in proportion to the area

ITEK-220 and ITEK-320 are designed for automatic commercial metering and telemetric control of supply and consumption of liquids, gases, steam and thermal energy in combination with any primary measurement converters of consumption, temperature, pressure and pressure drop with

standardized output parameters at supplier's (thermal power plant, district heat, boiler houses) and consumer's sites (industrial enterprises, public utility facilities) The ITEK-X20 devices are developed in conformity with requirements of RD-50-213-80, PR-34-70-010-85, State standard 6651-84 and P75 recommendetion of the Ministry of Health

The ITEK-X20 devices are intended for the facilities of the first metering group (up to 4 facilities) with a complex configuration of supply and recovery piping (ITEK-220), and for the facilities of the first or second metering groups (one facility) (ITEK-320)

PRD is a wide range pressure difference converter The PRD measurement device is designed for operation in automatic monitoring and control systems of technological processes and provides continuous conversion of the measured parameter into a uniform electric output signal It is a fast operating converter and can be utilized for conversion of pulsating pressure differences into a unified electric signal with time constant of up to 2 msec (maximum permissible operational excess pressure is 1 6 MPa and 40 MPa)

Annual energy savings

In 1997 the plant used approximately 7,530,000 kWh of electric power, 2,530,000 m^3 of natural gas
The global experience and practice confirm that quality monitoring of energy ensure 5% of fuel and energy consumption savings Energy savings at the works will amount to
1) Electric power - 7,530,000 x 0 05 = 376 thousand kWh
2) Natural gas - 2,530,000 x 0 05 = 126 thousand m^3

Annual cost saving estimate

1 At the price of $0 046 per 1 kWh of electric power the cost savings will be
376,000 x 0 046 ~ $17,000
2 At the price of $83 per 1,000 m^3 of natural gas the cost savings will be
126 x 83 ~ $11,000
Total fuel cost savings will be
17,000 + 11,000 ~ $28,000

Implementation Costs

Approximate cost of the ITEK automatic metering system is $35,000

Simple payback

Implementation costs - $35,000
Annual cost savings - $28,000
Simple payback period will be
35,000/28,000 ~ 1 3 (years)

A 3 ECO #3 Optimization of thermal and ecological parameters of gas firing equipment

ECO description

Currently the plant uses two dryer units and a boiler with highly organic heat medium The energy auditors took measurements of combustion gas composition with the ENERAC-2000 combustion analyzer Only at the BIZON dryer the gas analysis was satisfactory At the boiler with highly organic heat medium the burner unit operated with large air excess At the veneer dryers the lower burners were fired with resulting incomplete burning

The energy auditors think it necessary to optimize the operation of gas firing equipment in terms of both ecological and thermal parameters and catty out consistent supervision over gas combustion modes For this purpose it is suggested to utilize the ENERAC-2000 combustion analyzer The global practice shows that the use of this instrument will reduce fuel consumption by 2-5%

Annual energy savings estimate

Gas consumption at the plant in 1997 was 2,500 thousand m^3
Two per cent gas savings will be
2,500,000 x 0 02 = 50,000 (m^3)

Annual cost savings estimate

At the gas price of 0 083 per 1 m^3 cost savings will be
50,000 x 0 083 ~ 4,200 ($)

Implementation cost

ENERAC-2000 combustion analyzer	- $5,000
Overheads	- $1,000
TOTAL cost	- $6,000

Simple payback

Implementation cost	- $6,000
Annual cost savings	- $4,200

Simple payback will be
6,000/4,200 ~ 1 4 (years)

A 4 ECO # 4 Thermal insulation of surfaces with temperatures of over 60°C

ECO description

The FANPLIT complex receives steam from the 4th Kiev power plant at the price of $26 5 per 1 Gcal The steam is transported via trunk pipeline of 500 mm diameter to the central steam distribution unit of the plant From the central distribution unit steam is supplied to the users

The analysis of the steam distribution system resulted in the finding that some of the pipelines and equipment units are not thermally insulated The energy losses are due to the lack of insulation at pipelines and were measured by the infra-red remote thermometer

Particulars of non-insulated piping are given in the table below

#	Purpose of piping	Location	Length, L m	Diameter, D mm	Number of valves	t, °C
1	Steam	Workshop No1	1	102	2	140
2	Steam	Workshop No1	1	50	1	113
3	Steam	Workshop No1	1	219	-	90
4	Steam	Workshop No1	1 2	100	1	130
5	Steam	Workshop No1	0 5	219	-	130
6	Steam	Workshop No2	1	241	2	97
7	Steam	Workshop No2	2 5	108	-	80
8	Steam	Workshop No2	2	241	3	160
9	Steam	Workshop No2	3	100	1	145
10	Steam	Workshop No2	1	100	3	110
11	Steam	Workshop No2	1 5	197	1	120
12	Steam	Workshop No2	2	219	1	97

The gives the results of measurement of external surface temperatures

Annually the steam is consumed 7,200 hours on average

We recommend that the steam piping should be fully insulated The thickness of insulation should be selected dependent on the piping diameter and its purpose

	Purpose	Diameter, mm	Insulation thickness, mm
1	Steam	102 - 241	100
2	Steam	50 - 89	80

Annual energy savings estimate

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We should determine thermal energy waste for insulated and non-insulated pipes according to the methodology below [Methodological instructions for determination of losses of fuel and energy resources RD5 EDIV 015-008094 *Minmashprom*, Kiev, 1994]

Thermal energy waste in non-insulated pipelines (Kcal/hour) is determined by the following formula

$Q_{nin} = g_{nin} \times L_o \times k$

where g_{nin} - specific losses of non-insulated piping (Kcal/meter x hour),

k - correction factor depending on the outside temperature and difference between pipe outer wall and outside temperatures,

L_o - given length of piping, m

$L_o = L + (1m \times n) = 1 + (1m \times 2) = 3$ (m)

n - number of valves within the section

For the pipeline #1 from the Table we have

$Q_{nin1} = 670 \times 3 \times 0\ 95 = 1{,}900$ (Kcal/hour)

Further Calculations were carried out similarly and are summarized in the Table below

Thermal energy waste of insulated (Kcal/hour) pipelines is Calculated by the formula

$Q_{in} = g_{in} \times (t_1 - t_2) \times a \times b \times L_0$

where g_{in} - specific loss over 1 meter of piping with the difference $(t_1 - t_2) = 1^0C$ depending on the thickness of insulation, Kcal/m x hour ,

t_1 - temperature of pipe walls assumed as equal to temperature of heat carrier, °C,

t_2 - temperature of air, °C,

a - correction factor depending on the thickness of insulation, thermal conductivity if insulation material and temperature difference between heat carrier and air With insulation thickness up to 100 mm and temperature difference up to 200 °C $a = 1$,

b - wind correction factor (with wind velocity of 5 m/sec)

Presently it is realistic to cut down waste in the thermal networks by using modern efficient types of thermal insulation materials with thermal conductivity of 0 03 - 0 05 Kcal/ (m x hr x °C) We assume the use of these piping insulation materials

For pipeline #1 from the Table

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Q_{in1} = 0 231 x (143 - 10) x 1 x 1 04 x 3 = 96 Kcal/hr

Similar Calculations were carried out for all pipelines and are shown in the Table The savings are received taking into account the length of a pipeline

Pipeline No	Given length L_o, m	Thermal waste without insulation Q_{nin}, Kcal/hr	Thermal waste with insulation Q_{in}, Kcal/hr	Savings S_N, Kcal/hr
1	3	1,900	96	1,804
2	2	190	40	150
3	1	399	26	373
4	2 2	1,050	57	993
5	0 5	380	21	359
6	3	2,280	102	2,180
7	2 5	710	35	675
8	5	7,120	310	6,810
9	4	3,800	184	3,616
10	4	1,440	80	1,360
11	2 5	1,660	85	1,575
12	3	1,420	75	1,345
TOTAL				21,240

In the plywood workshop No1 at the drying line there are heat losses from non-insulated surfaces (T = 190°C) Total non-insulated area is F=4 m² The losses into the atmosphere are Calculated by the formula

$Q_2 = K \times F \times \Delta t$ (kcal/hour)

where

K = 6 5 kcal/m² x hour x C⁰ is coefficient of heat conductivity of structures

F = 4 m² - surface of heat exchange

$\Delta t = (t_{sur} - t_{air})$ is temperature difference

t_{sur} is the surface temperature

t_{air} is the surrounding air temperature

n = 7,200 hours

Heat losses at t_{sur} = 190°C, t_{air} = 20°C are Calculated independently

$Q_2 = K \times F \times (t_{sur} - t_{air}) =$

Q_2 = 6 5 x 4 x (190-20) 4,420 kcal/hour

Annual savings will be

$Q = 7{,}200 \times (Q_1 + Q_2) = 7{,}200\ (21{,}240 + 4{,}420) = 185{,}000{,}000$ (kcal/year)

or

Q = 185 Gcal/year

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Annual cost savings estimate

Cost savings for natural gas at the price of US$26 5 per 1 Gcal will be

185 x 26 5 = 4,900 ($/year)

Implementation cost

Insulation costs for 4 m^2 of surface at the price of $30 per 1 m2team piping is Calculated by the formula
30 x 4 =120 ($)
Cost of steam piping insulation is equal to
L x C = 20 x 33 = 660 ($)
where
L is total given length of steam piping, m,
C equals US$20/m - cost of 1 m of piping insulation,

Total estimated costs of insulation to be installed at the enterprise will be	US$780
Overheads 20%	US$230
TOTAL	US$1,010

Simple payback estimate

Implementation costs	US$1,010
Annual savings	US$4,900

Simple payback
1,010/4,900 = 0 2 (year)

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A 5 ECO #5 Energy efficient plant lighting

ECO description

The external lighting system of the plant area consists of lighting fixtures with 45 DRL - 250 high pressure mercury lamps The production buildings are lighted by 79 DRL - 400 high pressure mercury lamps The light flow of the DRL-400 lamp is equal to 23,000 lumen and service life is 6,000 hours, DRL-250 - 10,000 lumen and 2,400 hours, respectively

It is suggested to consider the proposal of replacement of DRL -250 high pressure mercury lamps for external lighting of the plant area and internal lighting with the DNaT-100-3 high pressure sodium lamps using existing fixtures and replacing switching appliances We recommend to replace the DRL -250 high pressure mercury lamps for internal lighting with the DNaT-100-3 high pressure sodium lamps using existing fixtures and replacing switching appliances

The proposed high pressure sodium lamps have the following Technical parameters

- DNaT-100-3 service life of 6,000 hours, light flow of 9,000 lumen,
- DNaT -250-3 service life of 12,000 hours, light flow of 25,000 lumen

Calculation of annual electric power savings

<u>The current electric power use for plant lighting</u>
Electric power use by a single external lighting fixture with DRL - 250 mercury lamp is

$P_{F1} = (P_{L\,1} + P_{SW,\,1}) \times \cos\phi$

where $P_{L\,1}$ = 250 W is equal to the capacity of the lamp,
$P_{SW\,1}$ = 54 1 W is capacity of switching appliances,
$\cos\phi$ = 0 98

P_{F1} = (250+54 1) x 0 98 = 298 Wh =0 298 kW
Amount of the power used by 45 internal lighting fixtures over 1 year at average 10-hour use is

P_1= 0 298 x 45 x 3,650 = 48,950 kWh

where 3,650 = 365 x 10 - annual time of lighting operation
Amount of the power used by 79 internal lighting fixtures over 1 year at average 10-hour use is

P_2= 0 298 x 79 x 2,500 = 58,900 kWh

where 2,500 = 250 x 10 - annual time of lighting operation
The electric power use by one lighting fixture with DRL-400 mercury lamp

$P_{F2} = (P_{L\,2} + P_{SW\,2}) \times \cos\phi$

where $P_{L\,2}$ = 400 W is the capacity of lamp,
$P_{SW\,2}$ = 100 W is capacity of switching appliances,
$\cos\phi$ = 0 98

P_{F2} = (400+100) x 0 98 = 490 Wh =0 49 kWh

Power used by 79 lighting fixtures over 1 year at average 10-hour use is

P_3= 0 49 x 79 x2,500 = 96,700 kWh

where 2,500 = 250 x 10 - annual time of lighting operation

Total use of electric power by the external and internal lighting systems is

$P^{cur} = P_1 + P_2 + P_3$ = 48,950 + 58,900 + 96,700 ~ 204,550 (kWh)

<u>The electric power use for plant lighting after implementation of the ECO</u>
Electric power use by a single external lighting fixture with DNaT - 100 - 3 sodium lamp is

$P_{F3} = (P_{L\,3} + P_{SW,\,3})$ x cosϕ

where $P_{L\text{-}3}$ = 100 W is equal to the capacity of the lamp,
$P_{SW\,3}$ = 10 W is capacity of switching appliances,
cosϕ = 0 98

P_{F3} = (100+10) x 0 98 = 108 Wh =0 108 kW

Amount of the power used by 45 internal lighting fixtures over 1 year at average 10-hour use is

P_4= 0 108 x 45 x 3,650 = 17,700 kWh

where 3,650 = 365 x 10 - annual time of lighting operation

Amount of the power used by 79 internal lighting fixtures over 1 year at average 10-hour use is

P_5= 0 108 x 79 x 2,500 = 21,300 kWh

where 2,500 = 250 x 10 - annual time of lighting operation

The electric power use by one lighting fixture with DNaT-250-6 sodium lamp

$P_{F4} = (P_{L\text{-}4} + P_{SW\text{-}4})$ x cosϕ

where $P_{L\text{-}4}$ = 250 W is the capacity of lamp,
$P_{SW\text{-}4}$ = 25 W is capacity of switching appliances,
cosϕ = 0 98

P_{F2} = (250+25) x 0 98 = 270 Wh =0 27 kWh

Power used by 79 lighting fixtures over 1 year at average 10-hour use is

P_3= 0 27 x 79 x2,500 = 53,300 kWh

where 2,500 = 250 x 10 - annual time of lighting operation

Total use of electric power by the external and internal lighting systems is

$P_{est} = P_4 + P_5 + P_6 = 17{,}700 + 21{,}300 + 53{,}300 \sim 92{,}300$ (kWh)

Annual energy savings will be

$P_{cur} - P_{est} = 204{,}550 - 92{,}300 = 112{,}000$ kWh

Annual cost savings estimate

Cost savings at the price of electric power of US$0 048 per 1kW

112,000 x 0 048 = US$5,100

Implementation costs

Cost of DNaT -100-3 lamps with appliances - US$4,300
(124 at $35 each)
Cost of one DNaT -250-3 lamp with appliances - US$3,500
(79 at $44 each)
TOTAL cost - $7,800
Construction and installation costs not included since the work will be carried out by the plant personnel

Simple payback estimate

Implementation costs = US$7,800
Annual cost savings = US$5,100
Simple payback

7,800/5,100 = 1 5 years

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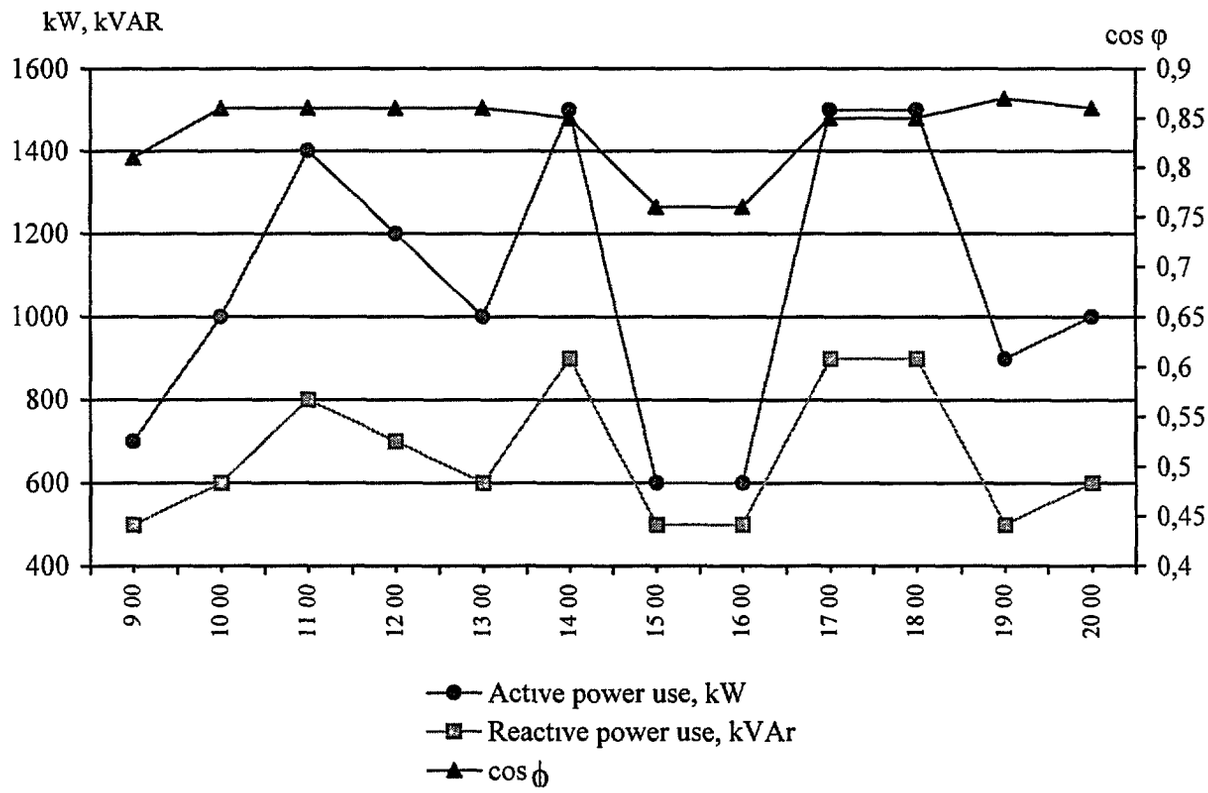
A 6 ECO #6 Optimization of thr refiner main drive of the BIZON equipment of fiber board unit

ECO description

In the overall electricity use balance the electric motor of the refiner main drive comprises 40% of active power load and 85% of reactive power load
Currently the main drive operation mode is continuous To drive the refiner an asynchronous high voltage electric motor is used with phase rotor of the following parameters

- nominal voltage 10 kV
- nominal current 108 A
- nominal capacity 1,600 kW
- power factor at the nominal load 0 87

Hourly electric loads measured
by active and reactive power meters on April 23,1998

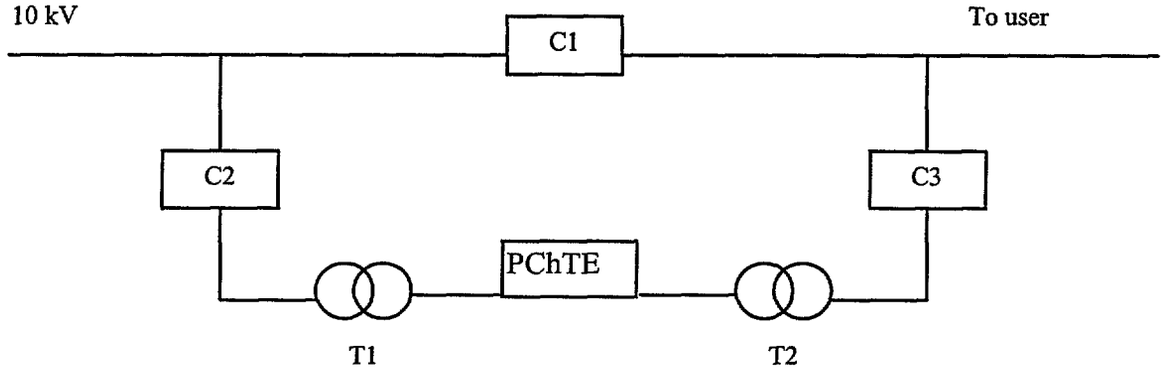


Average motor load was 1,100 kW at cosϕ = 0 84
By the meter readings in March 1998 average motor load was around 700 kW at average cosϕ = 0 74

In order to reduce power consumption we recommend to introduce variable speed control Utilizing variable speed drive smooth start and stop of the motor will be ensured Smooth control within the

prescribed load range will permit to automate (if necessary) the Technical parameters of the refiner operation If the drive load is zero or is dropping the power demand at the frequency converter output will cover the losses of the idle drive, i e 10-20% of the nominal capacity of the electric motor However, cosϕ will remain stable throughout the entire load range of the motor

In order to implement the variable speed drive capability for the main drive motor of the refiner we recommend to utilize a 1,600 kW frequency converter of the PChTE-2000 series manufactured by the Kharkiv research and development enterprise EOS ltd Given that the nominal PChTE voltage is 0 7 kV the following electric circuit is proposed ensuring utilization of the existing distribution panel cell (DP) as a by-pass for maintenance periods



C1	existing DP cell
T1	step-down transformer 10/0 7 kV - 1,600 kVA
T2	step-up transformer 0 7/10 kV - 1,600 kVA
C2, C3	cells of distribution unit for connecting and disconnecting variable speed drive

All equipment is manufactured in Ukraine

Annual energy savings estimate

Installation of the variable speed drive for the asynchronous high voltage electric motor of the refiner main drive will ensure 20% of electricity savings of the nominal capacity, i e not less than 300 kW With the round-the-clock operation during 250 days the savings will be
300 x 24 x 250 ~ 1,800,000 (kWh)

Annual cost savings estimate

At the electricity price of $ 0 46 per 1 kWh cost savings will be
1,800,000 x 0 046 ~ 82,000 ($)

Implementation cost

PChTE-2000 variable speed drive	$115,000
SP ABB transformer (2 units)	$60,000

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KP1F-10-630-20 cells (2 units)	$9,000
Installation and commissioning	$6,000
TOTAL cost	$190,000

Simple payback

Implementation cost	$190,000
Cost savings	$82,000

Simple payback
190,000/82,000 ~ 2 3 (years)

A,7 ECO #7 Plywood unit dryer oven upgrading

ECO description

For veneer drying in the plywood workshop a roller drying unit is used Exhaust gases are used as the drying agent Currently a primitive plant made up of a combustion chamber with two bottom burners, a chamber for mixing combustion products with air and recirculated drying agent is used for generation of the primary drying agent Supply of the drying agent from the mixing chamber and recirculation of the drying agent are performed by two DN 12,5 fans Each fan is equipped with a 75 kW electric motor While measuring the electric loads it turned out that their loads were 45 kW each

The combustion gas analysis showed the presence of carbon monoxide - 0 03% CO - indicating that with tenfold dilution of combustion products there are considerable losses of energy connected with incomplete combustion All attempts to eliminate incomplete combustion without reduction of heat generation failed to produce a positive result This implies the inadvisability of further operation of the present scheme of drying agent generation both from Technical and Ecological as well as from the economic point of view

The energy auditors see it expedient to dismantle the entire gas generation unit and replace it with a gas and air heater of the VGS type with 3 MW capacity For supply and recirculation of the drying agent one draught fan should be used, not two

By the experts' estimate implementation of this proposal will reduce gas consumption for veneer drying by 10 to 15% and electricity demand by 45kW

Annual energy savings estimate

In 1997 natural gas consumption was approximately 2,500,000 m^3 Out of this volume over 50% by the meter readings and by the experts' estimate were used for veneer drying in the plywood workshop Judging from the above data fuel (gas) savings will be
2,500,000 x 0 5 x 0 1 ~ 125,000 (m^3)

With the round-the-clock operation 220 days a year electricity savings will be
45 x 24 x 220 ~ 238,000 (kWh)

Annual cost savings estimate

1 With the price of gas at $0 083 per 1 m^3 fuel cost savings will be
125,000 x 0,083 ~ 10,400 ($)
2 With the price of electricity at $0 046 per 1 kWh electricity cost savings will be
238,000 x 0,046 ~ 11,000 ($)

TOTAL cost savings will be
10,400 + 11,000 ~ 21,400 ($)

Implementation cost

Design	- $2,000
Equipment	- $10,000
Air ducts and materials	- $2,000

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Installation and turnkey adjustment	- $8,000
Overheads and contingencies	- $2,000
TOTAL cost	- $24,000

Simple payback

Implementation cost	- $24,000
Annual cost savings	- $21,400

Simple payback will be
24,000/21,400 = 1 1 (years)

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A 8 ECO #8 Decentralization of thermal energy supply

ECO description

Currently the plant purchases thermal energy from the *Darnitsa* power plant The plant steam distribution unit receives saturated steam with the pressure of 8 kg/cm^2 and temperature of 178 - 180-^{0}C The plant uses from 2 to 6 tons of steam per hour The steam is used both for production purposes and space heating The primary steam consumers are the plywood workshop (2-2 5 tons per hour) and the BIZON production line (4 tons per hour) For the space heating of management office and auxiliary units around 0 5 tons of steam per hour are needed The condensate is not returned to the *Darnitsa* power plant and is used for wood treatment in the plywood workshop

Given the high purchasing price and the prospects of further increase the energy auditors see it expedient to decentralize the thermal energy supply The proposal is to install to modular automatic boilers near the plywood workshop and the BIZON production line respectively of 2 5 and 5 ton capacity In order to ensure flexibility, reliability and cost-efficiency of thermal energy supply the boiler units should incorporate two boilers each Going over to the in-plant thermal energy supply will reduce thermal energy cost and penalties for non-recovery of condensate, cut down losses in the communication lines

Annual energy savings estimate

By the experts' estimate transition to decentralized energy supply will reduce thermal energy consumption by 5 to 10% At the annual consumption of 12,700 Gcal the savings will be
12,700 x 0 05 ~ 600 (Gcal)
i e to implement the same production program 12,100 Gcal would be required

Annual cost savings estimate

In 1997 the energy bill amounted to ~$350,000 With the in-plant thermal energy supply consumption of fuel (natural gas) for generation of 12,100 Gcal of thermal energy at the specific use of 140 m^3/Gcal will be
12,100 x 140 ~ 1,700,000 (m^3/per year)

With the price of gas at $0 083 per 1 m^3 the cost of fuel for own thermal energy generation will be
1,700,000 x 0 083 ~ 141,000 ($)

By the experts' estimate operational cost will constitute 20% of the fuel cost i e taking into account operational cost the cost of the in-plant energy will be
141,000 + 141,000 x 0,2 ~ 170,000
Cost savings due to the in-plant supply will be
350,000 - 170,000 ~ 180,000 ($)

Implementation cost

Equipment	$330,000
Design, turnkey installation	$80,000
Overheads and contingencies	$10,000
TOTAL cost	$420,000

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Simple payback

Implementation cost	$420,000
Annual cost savings	$180,000

Simple payback will be
420,000/180,000 = 2 3 (years)
Considering that the thermal energy cost can go up to the 1995 level, i e constitute 740,000 $/year the payback period may not exceed 1 year

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APPENDIX B. PLANT PHOTOGRAPHS

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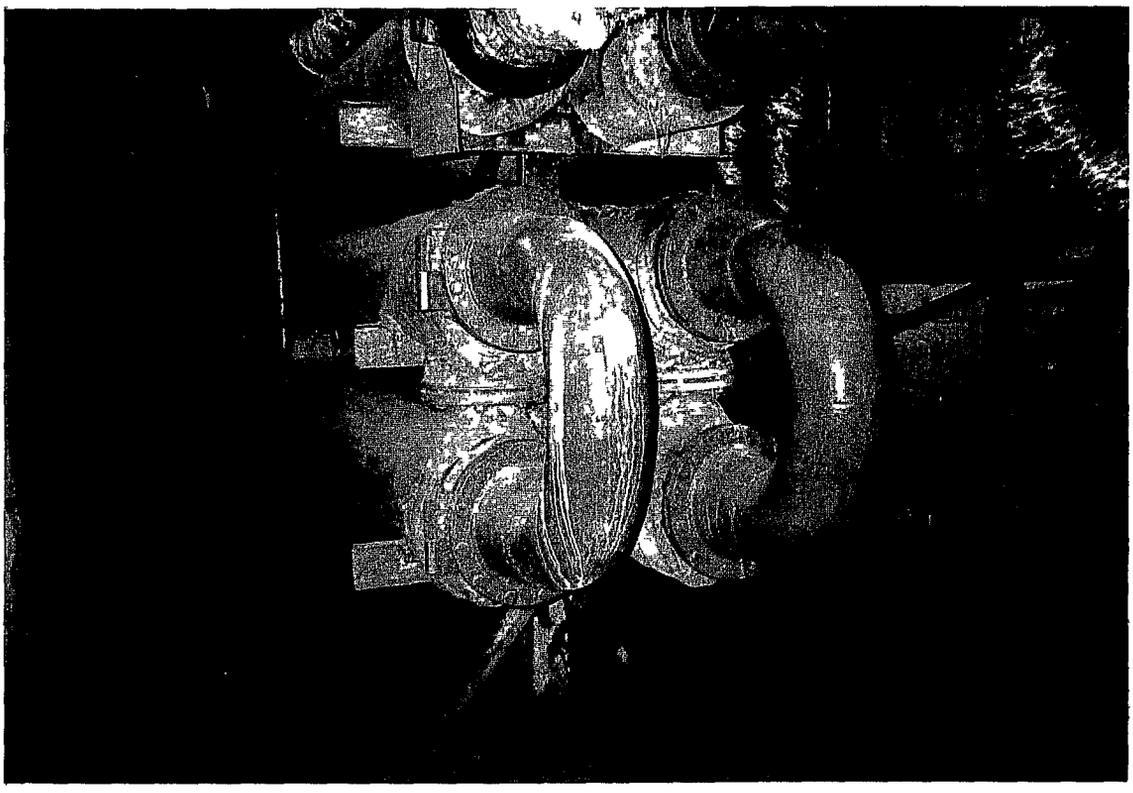
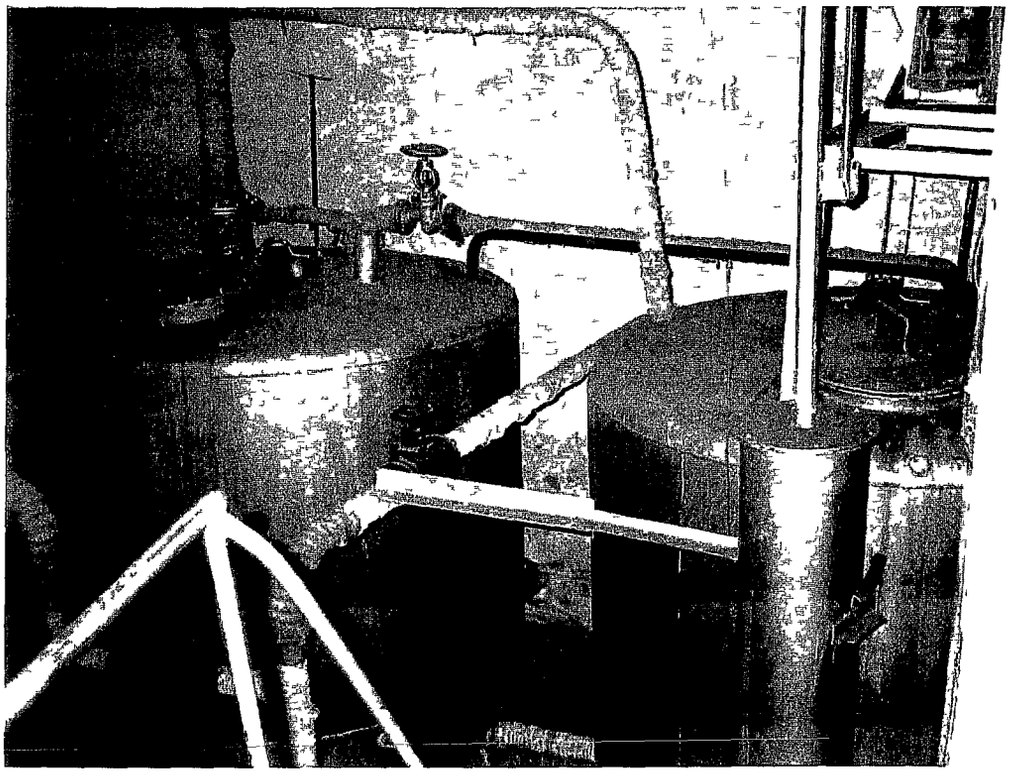


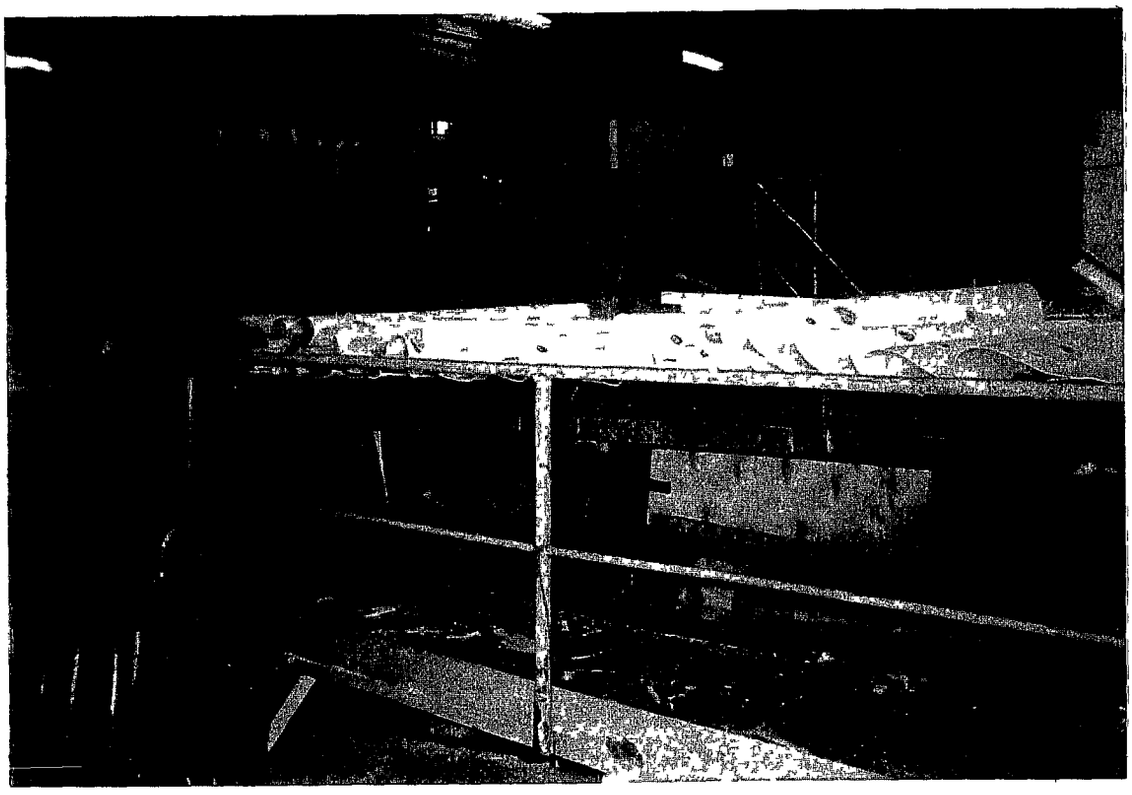
Теплообменники ценрального теплового пункта

Heat exchangers at the central steam distribution unit



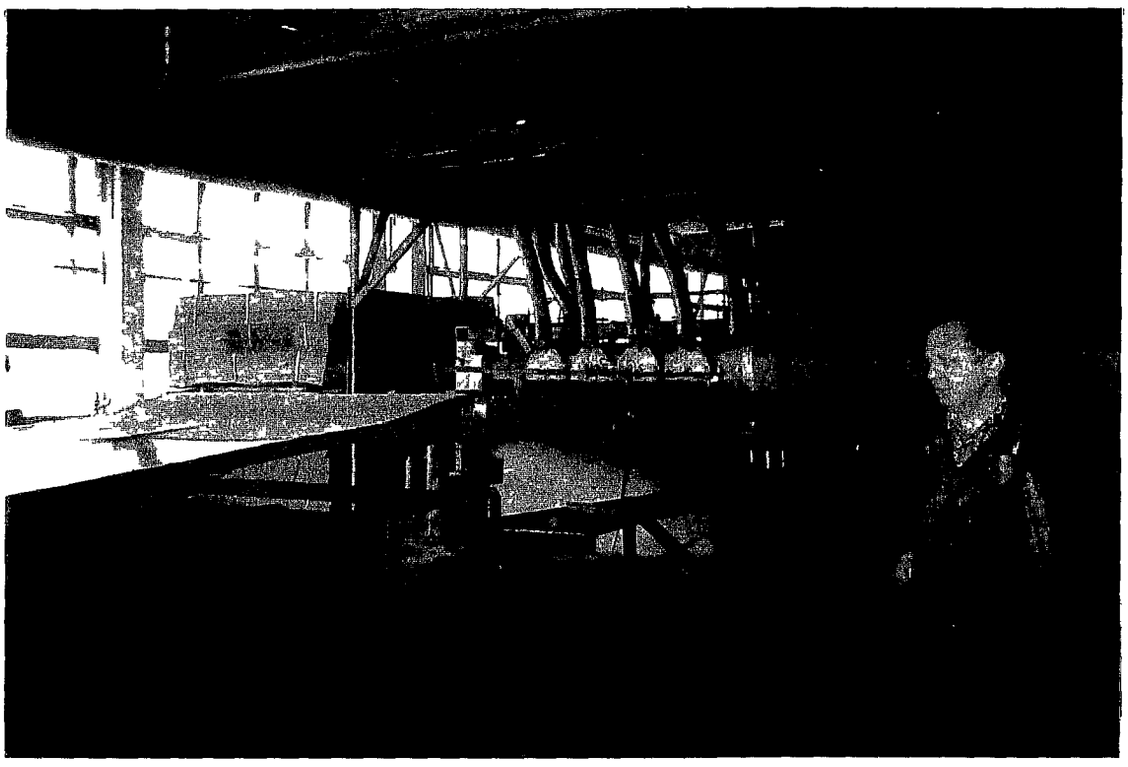
Конденсатное хозяйство фанерного цеха

Condensate equipment of plywood production line



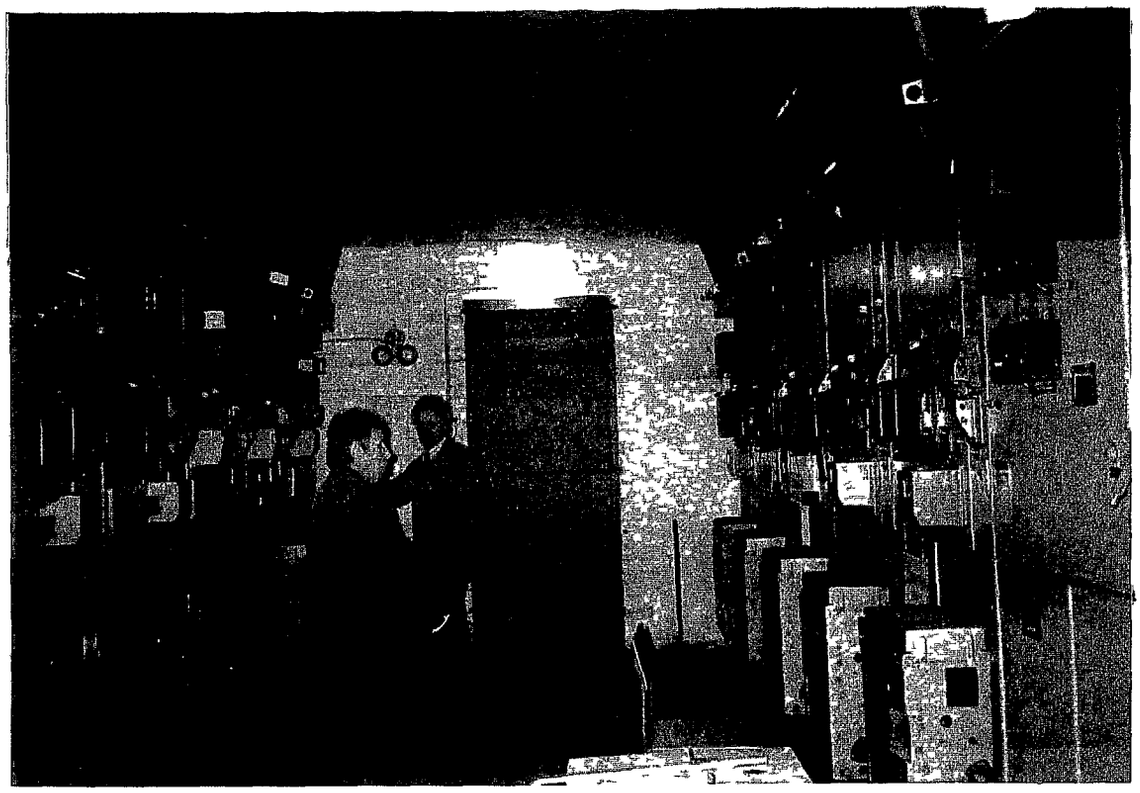
Цех производства фанеры

Plywood production line



Производство ДВП на линии “БИЗОН”

Fiber board production at “BIZON” line

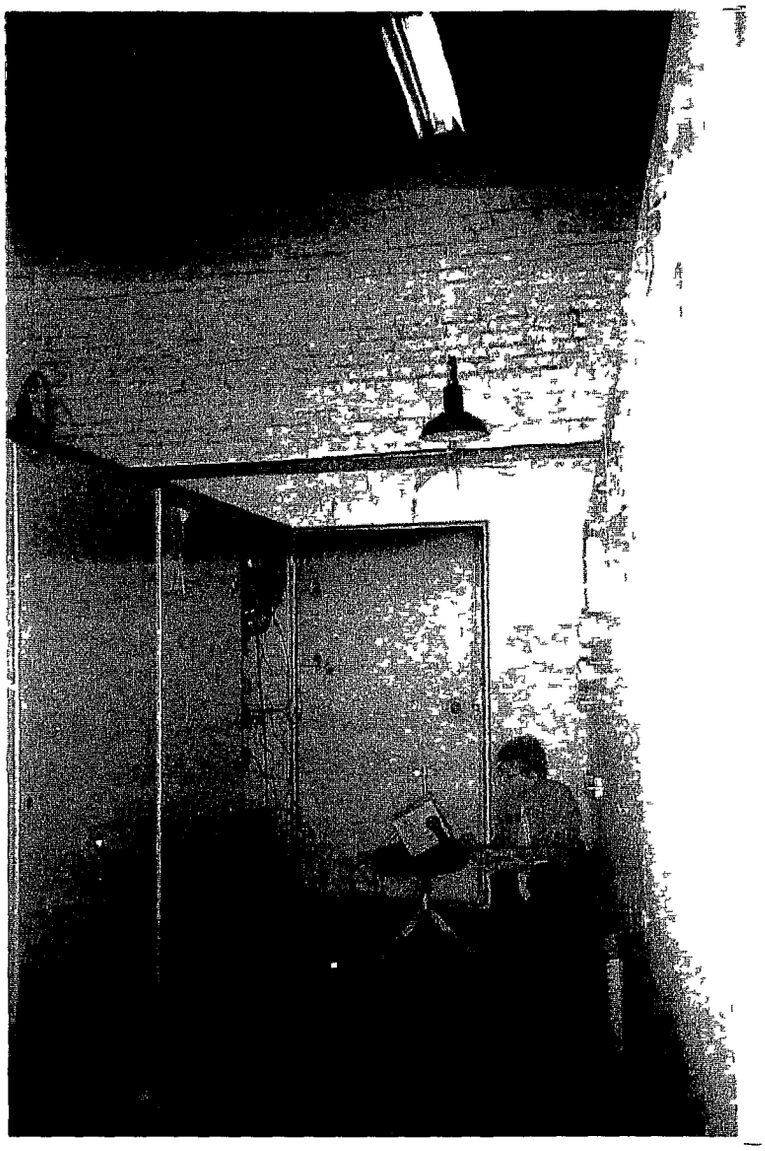


Закрытое распеделительное устройство завода “ФАНПЛИТ”

Closed-circuit distribution unit of FANPLIT plant

Складирование готовой продукции

Storage of finished products



Контрольные измерения электрических нагрузок линии производства ДВП “БИЗОН”

Electric load measurement at “BIZON” line of fiber board unit

APPENDIX C. ABBREVIATIONS AND UNITS OF MEASUREMENT

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Currency rates of exchange

1 hrivnia - local currency unit
1hrivnia = US$0 54 as of December 1997

Conversion factors

Heat

1 Cal = 4 187 J
1 kcal = 4 187 kJ = 3 968 BTU
1 Gcal = 4 187 x 10^3 = 4 187 GJ
1 BTU = 1055 J = 1 055 kJ = 1 055 x 10^3 MJ
1 tce (tonne of coal equivalent) = 7,000 kcal 3 968 BTU = 27,78 x 10^6 BTU = 27,78 MBTU

Power

1 W = 3 6 x 10^3 J = 3 6 kJ
1 kW = 3 6 x 10^3 kJ = 3 6 MJ = 860 kcal
1 MW = 3 6 x 10^3 MJ = 860 kcal
1 kcal = 1 163 x 10^3
1 Gcal = 1163 kW = 1 163 MW
1 kW = 1 36 HP
1 kW = 1 34 hp

Pressure

1 kg/cm^2 = 1 atm
1 atm = 101 325 kPa = 0 1 MPa
1 bar = 10^5 Pa = 100kPa = 0 1 MPa

Length

1 mm =0 03937 in = 0 00328 ft
1 cm = 0 3937 in = 0 0328 ft
1 m = 3 937 in = 3 281 ft

Weight

1 gram = 2 2046 x 10^3 lb
1 kg = 2,2046 lb
1 t = 1000kg = 2 2046 x 10^3 ft

Area

1 cm^2 = 0 155 square in = 1 076 x 10^3 square ft
1 m^2 = 1 55 x 10^3 square in = 10 76 square ft

C1

Volume

1 m^3 = 35 31 cu ft = 1000 l
1l = 35 31 x 10^3 cu ft
1l = 0 264 US gal

Heat content

1 kJ/kg = 0 43 BTU/lb
1 kJ/m^3 = 26 84 x 10^3 BTU/cu ft
1 MJ/m^3 = 26 84 BTU/cu ft
1 kcal/m^3 = 4,187 kJ/m^3 = 0 112 BTU/cu ft

Temperature

^{0}C = 0 56 (^{0}F-32)

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ABBREVIATIONS

CIS - Commonwealth of Independent States
ECO - energy conservation opportunity
ESCO - energy service company
etc - et cetera
Hr - hrivnia
i d - id est
JSC - joint-stock company
mln - million
TACIS - technical Assistance to CIS countries
tel - telephone
thou - thousand
US - United States
USAID - United States Agency of International Development

UNITS OF MEASUREMENT

BTU - British thermal unit
^{0}C - degrees Celsius
cm^2 - square centimeters
Cal - Calorie
0F - degrees Fahrenheit
g - gram
Gcal - gigacalorie
GJ - gigajoule
hr - hour
kcal - kilocalorie
kg - kilogram
kgf - kilogram-force
kV - kilovolt
kV-A - kilovolt-ampere
kW - kilowatt
kW h - kilowatt hour
Lm - lumen
m - meter
m^2 - meter squared
m^3 - meter cubed
min - minute
MJ - megajoule
mm H_2O - millimeters of the water column
MW - megawatt
t - tonne
tonne of coal equivalent
t/h - tonnes per hour
W - watt
yr - year

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