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ENERGY AUDIT
AO RIAT
IVANOVO
RUSSIA

Prepared for

US AGENCY FOR INTERNATIONAL DEVELOPMENT
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Prepared by

Hagler Bailly Services, Inc
1530 Wilson Boulevard, Suite 900
Arlington, VA 22209-2406
(703) 351-0300
and
East West Energy Agency
Moscow, Russia

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The contents of this report include recommendations based on data provided by the client organization, measurements made on site, calculations and engineering judgement The conclusions reached were based on a limited engagement of less than ten days duration at the enterprise and not an exhaustive engineering analysis Hagler Bailly Services, Inc certifies that this report conforms to the level of best commercial practice for industrial energy audits of similar level of effort, as conducted in the United States This report has been prepared under the guidance of a registered Professional Engineer, licensed to practice in the United States

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SECTION 1

EXECUTIVE SUMMARY

Cost-effective energy efficiency measures can result in large savings for an industrial enterprise, thus releasing money spent on energy for other important uses by the management of the enterprise These cost savings can help to make the enterprise stronger, more productive and more competitive

One of the programs sponsored by the United States Agency for International Development (USAID) is the Energy Efficiency and Market Reform Project for Russia (Contract No CCN-0020-C-00-152-00) As part of this project, a team of engineers from East West Energy Agency in Moscow, led by Hagler Bailly carried out site activities at the AO RIAT facility in the Ivanovo Region Their objectives were to work with the enterprise personnel and technical personnel from Ivenergo and to identify opportunities for improvements in energy efficiency of the various industrial processes at AO RIAT

During the site visit, a vast amount of data was collected on the operating characteristics of the facility, the equipment installed, and the energy usage Metering and measurements were done at key locations to determine the energy usage levels and operating efficiencies of the equipment All of this information was then analyzed by the energy efficiency experts and evaluated for areas of potential improvements These evaluations resulted in some recommendations for implementing cost-effective modifications to improve the energy efficiency of the enterprise

Based on the recommendations, the estimated overall savings for all energy efficiency measures for AO RIAT is 670 9 million rubles per year Table 1 is a summary of these recommendations The table shows each recommended measure and includes the estimated costs and benefits, together with the simple payback for implementing these

The management of AO RIAT should review these energy efficiency measures and the costs and benefits of each A decision on the measures to be implemented and the determination of the financing for these should occur as soon as possible Following that, the specifications for equipment and business plans for implementation will be written These will be used in the financing arrangements Once approved the energy efficiency measures will be procured and installed

While making the calculations related to the efficiency of using various measures the following assumptions were made

1 The recalculation of the saving amount was done in natural terms While using the saving percentage during the implementation of a specific measure the recalculation was done against a 1996 level of consumption

2 During the translation of the saving amount expressed in natural terms into cost terms, the following tariffs for energy resources that were applicable when the energy study was performed were used

- Electricity 560 rubles per kW/h
- Natural gas 289 177 rubles/thousand m^3 of natural gas
- Water consumption 317 rubles/m^3

3 During the translation of rubles into US dollars we used the exchange rate of 5700 rubles for each USD

4 During the recalculation of tons of reference fuel into thousands of m^3 of natural gas, we assumed that natural gas heating value was at the level of 8000 Ccal/m^3 of natural gas (reference fuel has heating value of 7000 Ccal/kg)

5 During the recalculation of heat losses in the heat supply system expressed in Gcal into thousands of m^3 of natural gas we assumed that boilers efficiency was at the level of 90%

6 During the calculations of capital repayment bank interest was not taken into account (simple repayment)

Table 1
Recommended Energy Efficiency Measures for
AO RIAT

No	Description of Measure	Units of Measure	Annual Energy Savings	Annual Savings in M Rubles	Cost of Measure M Rubles	Simple Payback Period
1	Computerized system of metering and control	Mwh	210	117 9		
		tsf	244 1	61 8		
		Tcm (gas)	213 6			
		TCM (water)	10 2	3 2		
		Total measure		182 9	185	1 year
2	Thermal Insulation of Pipelines Boilers etc	Tcm (gas)	69 4	10	20	6 months
3	Installation of Steam Traps	Tcm (gas)	890	257	11 4	< 1 month
4	Stop valve inspection/repair	Tcm (gas)			1 14/valve	*
5	Combustion controls	Tcm (gas)	35 6	10 4	5 13	6 months
6	Combustion controls of air/gas ratios	Tcm (gas)	35 6	10 3	22 23	2 + years
7	Installation of Stop valves in major air ducts	Mwh	31	17 4	2 1	< 2 months
	Total for all Measures			670 9	245 86	5 months

* Savings depends on the number of valves replaced or repaired

Section 2

Introduction

The purpose of conducting the energy audit at AO RIAT was to collect and analyze appropriate data and information about the enterprise and the energy usages within the facility, then use this information to make recommendations on cost-effective measures to increase the efficiency level of the plant The process involved the collection of historical use of electricity, gas, coal and other fuels and their associated costs It also involved some metering and measurements of key energy using equipment at the facility This was done using the most current and sophisticated energy auditing equipment available

Units and components for cars are main products of the enterprise Major technological equipment of the enterprise was manufactured in Russia, there is a small amount of imported equipment Requirements in steam and hot water for technological purposes as well as heat load of the heating and hot water supply systems are met by the enterprise s own boiler house

The purpose of the survey energy audit is the evaluation of the potential saving of energy resources at the enterprise and the use of the findings to prepare recommendations for enhancing efficiency of energy use

A detailed description of each project with the indication of possible savings, necessary capital costs and periods of capital repayment are given in the section "Recommended Projects"

Section 3

Enterprise Description and Energy Consumption

In order to better understand the overall situation with the enterprise and it=s energy use, it is important to look at the characteristics, operations, processes and energy requirements This section provides the description of the enterprise, followed by a description of the facility itself, and then a description of the energy uses and requirements After that is a description of the data collection from the measurements and metering that was done during the energy audit

A Enterprise Description

AO RIAT is a metal processing enterprise of car industry that used to specialize in overhauling cars, buses and in upgrading units that they are made of, in making a small product line of spare parts

Over the recent years a drastic decrease in industrial orders to upgrade cars and their units has taken place due to decline in demand for upgrading works

The administration of the enterprise has taken some organizational and technical measures to help the enterprise enter a market economy, stabilize the economical situation

1 A transfer to the output of products for the Zavolzhsky Engine Factory (ZMZ) and Gorkovsky Car Works (GAZ)

2 Organization of output of parts and units for GAZ cars and units for their further sales through retail network

3 Organization of a technical maintenance service for domestically produced and imported cars

4 Retooling the production by establishing a shop to produce lumber products, a sewing shop to make bedding and sewing goods, a factory bakery to make bread

5 Opening shops to sell foodstuffs and manufactured goods, establishment of a car and filling station

B Facility Description

The facility at AO RIAT includes the following major structural divisions

- Shop of rebuilding and making parts (SRMP)
- Shop of rebuilding engine parts (SREP)
- Car repairing section
- Car technical maintenance station
- Sewing shop
- Lumber working shop
- Repairs and construction shop
- Chief mechanical engineer department
- Bakery
- Instrumentation shop

- Transportation shop
- Boiler house
- Compressing house

The total area of the enterprise is 40,968 m^2, the production area is 18,851 m^2

The following is a brief description of the enterprise divisions

The shop of rebuilding and making parts produces units and parts for the Zavolzhsky Engine Works and Gorkovsky Car Works as well as spare parts for sales through retail networks

Main products of the shop are water pumps, clutches, engine pistons, gear boxes, sockets for directing valves, linings for cylinder heads, etc

The shop has a stock of aggregate and metal-cutting machine-tools, digital control machine-tools, a cold stamping section, a thermal section equipped with HFC units, electrical heating furnaces from 30 to 100 kW as well as an electrolytic bath for hardening gears in salty melts a forge shop equipped with gas heating furnaces, a casting section for casting pig-iron into molds equipped with electrical crucible furnaces, a welding and fusing section equipped with a unit for fusing parts in the medium of carbon dioxide, a unit of short-circuit arc surfacing, gas and electrical manual welding stations

The shop for rebuilding engine parts makes upgrades of engines ZMZ-53 and GAZ-52 as well as manufactures spare parts and units

The shop is equipped with general purpose metal-cutting equipment and specialized equipment for rebuilding and making engine parts In addition to this, the shop includes a section for upgrading a ZMZ-402 engine supplied to Ulyanovsk Car Works to be installed in special cars, this section is equipped with a high-precision processing center IS-8000, digital control machine-tools, special stands for testing engines, a galvanic section that performs iron plating and phosphate coating of parts during their repairing and manufacturing

The section of cars repairs makes welding and fitting works to repair car bodies on a custom-made basis and makes custom-made consumer goods (stoves for saunas, metallic garages, vans for trucks)

The station of technical maintenance maintains cars of all brands produced in the country and abroad and performs the following types of work washing, diagnostics repairing and adjustment of instruments, replacement of parts, units and aggregates

The station is equipped with 8 electrical and mechanical hoisting mechanisms, metal working machine tools, car washing posts, various diagnostics devices

The sewing shop makes bedding, and implements orders for making sewing goods of light cloths The shop is equipped with machines for cutting and rewinding material as well as all kinds of sewing machines

Lumber working shop specializes in making door and window frames for residential many-flat buildings The shop has two dry kilns for lumber drying All equipment for making frame parts, their painting has been manufactured in Germany and is of high quality

The chief mechanical engineer department performs maintenance and repairing of metal-cutting equipment, lifting and transportation equipment, transformer substations, electrical grids, industrial ventilation systems The shop is assigned the task of providing the enterprise with electric power, steam, hot and cold water, compressed air

The instrumentation shop makes and repairs equipment, fixtures, cutting measuring tools, as well as off-size equipment The shop is equipped mostly with metal cutting machinery

The supervision over the production activity of the enterprise is implemented by the production and dispatch department headed by the deputy General Director for production by performing a daily management of the shops and section operation

The production process for implementing production tasks is controlled, coordinated and regulated at the operative meetings

The production department develops a production annual plan with the breakdown of works on a quarterly basis on the basis of the contracts concluded with the consumers of the products and is sent to the shops and the sections of the enterprise after it is approved by the General Director

In the past during the manufacture of the products for upgrading cars and units, the design work was performed by KTB of the Russian Automobile Ministry and the technical department of AO RIAT At the moment all developments are conducted by the engineering center of AO RIAT and sometimes the work is performed on the basis of contracts concluded with outside design companies

PRODUCT OUTPUT

Table 2 presents information on the production and financial activity of the enterprise

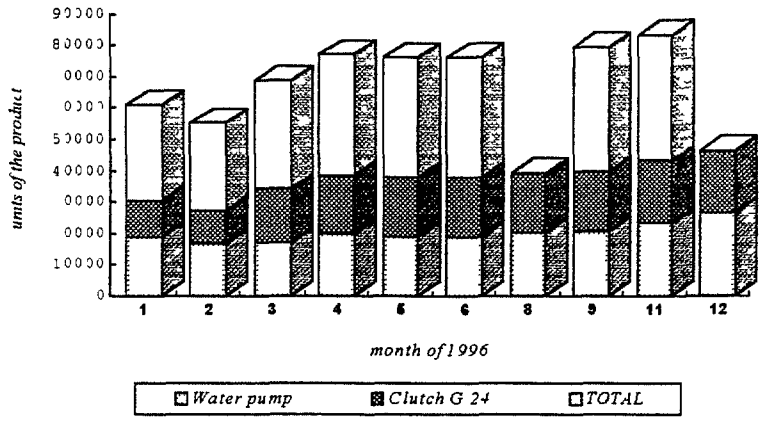
Tables 1-3 of the Appendix present data of the product output in 1994-1996

Table 2 Main Performance Factors of the Enterprise in 1994-1996

#	Item	Unit	1994	1995	1996
1	Production output	ml rubles	12 996	30 940	34 438
2	Profit from sales	ml rubles	3378	576	232
3	Fixed assets	ml rubles	6140	18963	36462
4	Average number of personnel	Person	804	751	579
	including industrial and production personnel	Person	698	674	533
6	Labor productivity	Thousand rubles/pers	18619	45905	64512
7	Average revenue per one employee	Thousand rubles	108 4	346 5	687 8

Water pump 4022 and clutch G-24 account for almost three quarters of the product output of the enterprise in cost terms Figure 1 shows dynamics of this product output by months of 1996

Figure 1 Dynamics of the Main Product Output in 1996



The data presented shows that the production at the enterprise is stable and there is a clear tendency for growth

C ENERGY CONSUMPTION

Table 3 shows data on the consumption of natural gas, electricity and city water in natural terms and cost terms

Table 3 Consumption of Natural Gas Electricity and City Water at the Enterprise in Natural Terms and Cost Terms

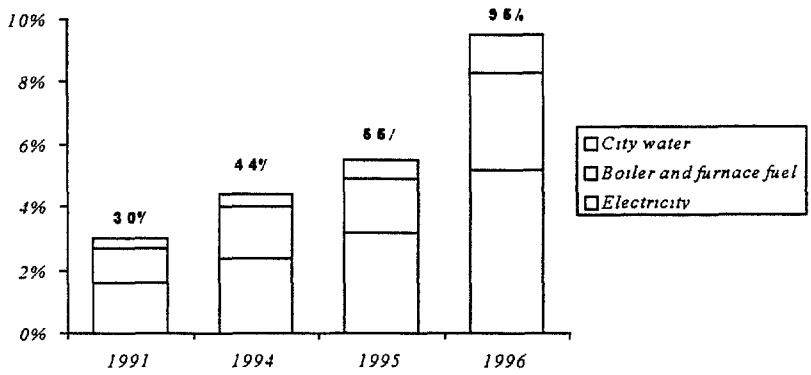
#	Item	1991	1992	1995	1996
1	Product output million rubles	37 8	12 966	30 940	34 438
2	Boiler and furnace fuel consumption tons of reference fuel	n/a	3 837	3 790	4 068
	the same in million rubles	0 406	213 3	515 4	1 082 5
3	Electric power consumption thousand kW/k	n/a	4 620	4 244	4 214
	the same in million rubles	0 598	314 5	1000 7	1 781 9
4	Water consumption thousand m^3	n/a	165	197	201 9
	the same in million rubles	0 103	54 3	195 7	406

The dynamics of the energy costs growth over the period of 1991-1996 is presented in Table 4 and Figure 2

Table 4 Ratio of the Share of Energy Costs to the Total Output (%)

Energy resource	*1991*	*1994*	*1995*	*1996*
Electricity	1 6%	2 4%	3 2%	5 2%
Boiler and furnace fuel	1 1%	1 6%	1 7%	3 1%
City water	0 3%	0 4%	0 6%	1 2%
TORAL all energy resources	3 0%	4 4%	5 5%	9 5%

Figure 2 The Share of Energy Costs in the Total Output (%)



Therefore, we see a stable tendency for growth as regards the share of costs for energy resources relative to 1991, in 1994 it increased by 1 47 times, in 1995 - by 1 83 times, in 1996 - by 3 16 times

It is possible to forecast with a high degree of probability that in the future the tariff for energy resources will increase which will result in an increase of financial expenditures

Energy Resource Consumption in 1996

In 1996 the share of energy resources to the output amounted to 9 5%, at the same time electricity costs accounted for more that half of these costs (5 2%) Other costs in the order of decreasing are as follows boiler and furnace fuel (3 1%) and city water (1 2%)

Table 5 presents data on energy resources consumption at the enterprise in 1996 in natural terms and dynamics of fuel consumption and electricity consumption in 1996

Table 5 Energy Resources Consumption in 1996

#	Resource	Unit	Consumed amount by months												
			1	2	3	4	5	6	7	8	9	10	11	12	year
1	Fuel	tons of standard fuel	537	509	726	307	107	201	166	161	194	257	360	543	4068
2	Electricity	Thousand kWh	405 6	440 8	353 3	316 2	275 6	276 1	260 2	306 2	306 6	425 5	384 2	464 4	4213
3	City water	Thousand m^3	16 6	18 7	22 7	17 9	16 4	13 6	16 9	16 7	18 3	17 9	14 4	11 8	202

Metering Energy Resources Consumption

AO RIAT has limited supplies of gas, water and electric power, a limited supply of energy resources is set for each enterprise of Ivanovo based on calculations submitted to the utility enterprise

Commercial metering at the enterprise deals with

- Electric power consumption

  Electricity supply to the enterprise is made along cable lines from the substation Iv-2 of Ivenergo, the settlement of accounts is done in accordance with the readings of the meters-adders-ERSmik 32 (active and reactive power) installed on the feeders F608 and F624

- Natural gas consumption

  Ivanovogorgaz is a natural gas supplier, payments are made on a monthly basis in accordance with the readings of the meter RG-600 installed at the gas distribution station with a transmission capacity of up to 2000 m^3/hour It is necessary to note that when the survey of the enterprise was being conducted the gas meter was faulty and payments for natural gas consumed were made based on the readings of the gas supplying organization

- City water consumption

  Gorvodokanal is a water supplier delivering the water through four connecting lines each of which has an installed water meter

  A system of recycled water supply to cool compressors of the compressing station and freezers of the canteen was installed, it reduced the city water consumption The recycled water supply system uses a cooling tower the operating conditions of which may be recognized as unsatisfactory, a question on its rehabilitation or construction of a new cooling tower has been raised

- Consumption of heat generated by the enterprise boiler house

  The boiler house is equipped with 3 steam boilers, there is no metering of steam supplied to the on-site consumers Annual output of heat power is determined on the basis of natural gas consumed, boilers capacity and their efficiency which is, in fact, a very approximate evaluation of the quantity of heat generated

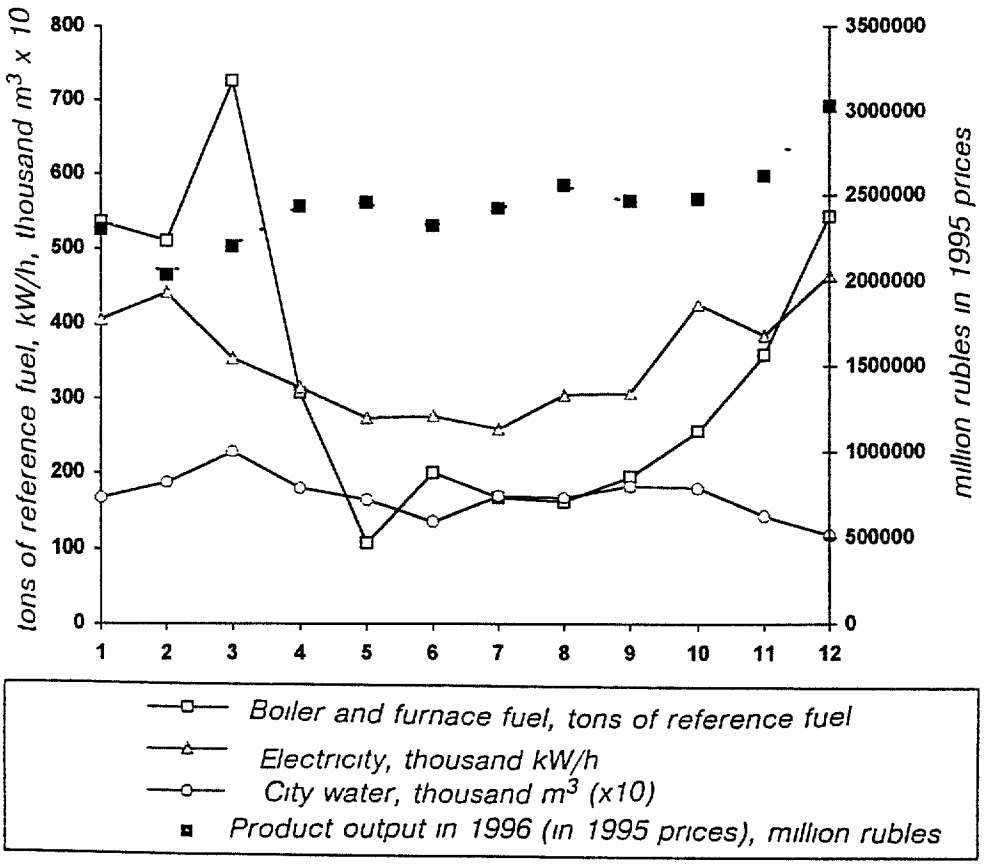
The lack of metering of energy resources at the enterprise is a major problem in the field of energy efficiency It is known from experience that a lack of a modern computerized system of complex energy resources metering not only makes the work of the departments more difficult (for example, during the preparation of request for energy resources supply) but also makes analysis and forecasting of the energy facility development and the enterprise impossible

D Energy Audit Data Collection

Some of the historical information gathered during the energy audit is shown in Figure 3 The graph of 1996 data shows

- Dynamics of of energy resources consumption by the enterprise in 1996 in absolute terms
- Dynamics of the product output by the enterprise In this case to get representative data, the amount of product output is presented in 1995 average prices

Figure 3 Dynamics of the Product Output (in 1995 prices) and Energy Resources Consumption in 1996



It is difficult to analyze the structure of the energy consumption by the enterprise since the consumption of any given energy resource does not, apparently, correlate with the output of major products

THERMAL TECHNICAL EQUIPMENT

The source of heat at the enterprise is a boiler house equipped with three steam boiler units Generated steam with the pressure of up to 4 5 atmospheres[1] is used at the enterprise for the following purposes (in % to the total output)

- Heating 40%
- Hot water supply 40%
- Technological purposes 20%

Boiler House and Communications Lines

MAJOR EQUIPMENT OF THE BOILER HOUSE

Three steam boilers, two boilers DKVR 6 5/13 and one boiler DKVR 2 5/13 manufactured by Biysk Boiler Factory are installed in the boiler house of the enterprise

Major consumers of the steam generated include the heating system of the enterprise and the hot water supply system, steam consumption for technological purposes is insignificant

The following equipment is installed in the boiler house

- three boilers for heating delivery water of the heating system
- two boilers for heating water of the hot water supply system

BOILER OPERATION

Boilers operation is conducted manually by changing gas and air pressure before the burners Gas-air ratio is maintained in accordance with the mode charts of the boilers, but air pressure devices have such ranges and resolution that do not allow the operating personnel to maintain the mode in accordance with the mode chart (not only in case of partial loads) It is also necessary to emphasize that there are no steam flow meters in all boilers, the personnel bases its work on the pressure of the steam supplied

RESULTS OF THE BOILER TESTING

Testing of boiler DKVR 6 5/13 rg # 4898 was conducted in April 4, 1997 It included measurements of flue gases content before and after the economizer, percentage of O_2, CO, NO_x, SO_2, as well as the temperature of waste gases Electronical gas combustion analyzer BACHARACH of the 300NXEB model was used Necessary readings of the flow meters and pressures were taken fiom the device control panel

"The technique" for making measurements included the following standard procedure

- Taking 'photographs' of the equipment operation with the aim of evaluating how the personnel followed the mode chart of the boiler unit operation

[1]At the moment of the study performance steam pressure behind the boiler was 4 5 atmospheres based on the readings of the device installed Steam pressure in the boilers did not exceed 3 5 atmospheres based on the readings of the devices installed

- Setting the boiler mode that would correspond to the mode chart (in the event the personnel does not follow the mode chart) or the optimization of the combustion mode with the aim of checking if the mode chart was prepared correctly

The results of the tests and heat losses calculation are present in Table 4 of the Appendix

The testing of the boiler DKVR 2 4/13 was conducted in June, 24 and the results of the testing are presented in Table 5 of the Appendix

The following general conclusions can be made based on the results of the boilers testing

1 The personnel maintained the operation mode of the boiler unit that was similar to the mode chart (the column 'Mode Photography") It is necessary to emphasize that available control instrumentation devices and regulating fixtures do not allow the personnel to follow the mode chart accurately

2 Optimization of the combustion mode conducted with the help of the gas combustion analyzer allowed to increase efficiency of the boiler units by 1 25% and 2 5% respectively due to decreased losses with waste gases

3 Heat losses with chemical underfiring are practically absent Losses of heat into the atmosphere q_5 are within standard values

CONDITIONS OF THE THERMAL INSULATION

As a result of a visual survey of the steam distribution system, data on the availability of insulation and its conditions was gathered In accordance with the estimates of the working group, nearly 100% of the pipelines are uninsulated Only steam pipelines within the boiler house have insulation Not a single gate and not a single flange available have insulation All analyzed boilers of the enterprise except for a "fast" boiler of the hot water supply system as well as hot wells do not have external thermal insulation
During the performance of the works aimed at conducting the energy study, a complete lack of steam traps at the steam consuming units was identified Two heating boilers, two boilers of hot water supply and two steam dry kilns of the lumber working shop may be referred to major steam consuming units In the recent past steam was used for technological purposes (washing machines), but its share is small (less than 10%) and is constantly decreasing, as the experts think, it can be neglected

Not a single unit has a steam trap Not a single boiler is equipped with the indicator showing the level of condensate in the unit In connection with this, certain part of steam is not used properly in the units and "flies" through them The situation is aggravated by the fact that the length of the condensate lines from the units to the hot wells is small (it does not exceed 40 m) Flying steam that does not have time to condensate in the condensate lines gets to the hot wells and through their exhausts it gets into the atmosphere A visually powerful steaming at the hot well exhausts is explained by this

Consumers

The list of the units that use steam or hot water is given in Table 6

Table 6 The List of Units that Consume Steam and Hot Water (data submitted by the enterprise)

#	Unit	Number of Units	% of condensate recovery
1	Steam water heater	3	100
2	Throughput washing machine steam	3	100
3	Round washing machine steam	5	100
4	Zherdev washing machines steam	2	100
5	Washing machine Eleon steam	2	100
6	Galvanic section of SRMP steam		100
7	Steam dry kilns of the lumber shop	2	100

It is necessary to note that the share of steam used for technological purposes is continuously decreasing which is connected with a refusal to use steam in the technological processes and dismantling of the steam consuming production machinery Washing machines are being dismantled At the moment steam dry kilns for lumber installed in the lumber working shop is the main (around 90% of the steam generated for technological purposes) consumer of the technological steam

Steam for heating purposes is supplied to two heating "new' boilers[2] One "new" and one "fast" boiler operate in the system of the hot water supply Two heating boilers have additional heat exchange surfaces (pre-heaters of the delivery water)

It is only the 'fast' boiler of the hot water supply system that has thermal insulation

The boilers are not equipped with instrumentation devices for checking the level of condensate in the boilers

Not a single consumer has steam traps installed

During the visit of the production shops the following information was obtained

- The condition of glass in the lamps installed in the production shops is satisfactory
- Air channels of the exhaust ventilation on the roof of the production shops are closed (as of April 20, 1996, when the study was conducted)
- The doors of the production shops have return mechanisms that prevent a random opening of the door
- Temperature mode in the production shops is satisfactory

ELECTRIC POWER SUPPLY AND ELECTRIC POWER CONSUMPTION

Electric power supply of the enterprise is conducted from two transformer substations TP-1 and TP-2

[2]The operating personnel uses this term in reference to boilers For example in the boiler house there are three "new" boilers installed (each) two heating boilers and one for hot water supply In addition to this there are two "fast" boilers (each) in the system of the hot water supply one of which cannot operate

TP-1 substation is installed in the SRMP and has two 1000 kVA transformers and one 630 kVA transformer

TP-2 substation is installed in the SREP and has three 1000 kVA transformers

Voltage of all transformers is 6/0 4 kV

4213 thousand kW/h were consumed in 1996

Due to idle capacity of the enterprise and its retooling at the present period, the following equipment is operated at the moment

- One 1000 kVA transformer and one 630 kVA transformer in TP-1
- Two 1000 kVA transformers in TP-2 which amounts in total to 3630 kVA

Therefore, the total installed capacity of the transformers is 3,630 KVA

The average annual fund of labor time is 4016 hours and the average load amounts to around 1050 kW It is possible to say that the load of transformers is low

It is useful to build curves of dependence of losses on the load under various options of connection in order to determine an economic mode of operation for simultaneously turned on transformers that provides minimal losses of electricity in them (especially in case of availability of transformers that have different capacity) and, on their basis, develop proper operation modes

Factors of installed capacity (kW) of electrical devices by all major consumers and by its use are presented in Table 7

Table 7 Installed Capacity of Major Electricity Consumers (kW) (data submitted by the enterprise)

#	Facility	Technological units	Combined extract and input ventilation	Lightning	Average labor time fund
1	SRMP	2860	105	30	4016 h
2	SREP	4042	150	40	-
3	Instrument Shop	540	35	20	-
4	Chief m engineer	860	32	20	-
5	Lumber shop	78	80	15	-
6	Total industrial facilities	8380	402	125	

Energy and technological modes in most production processes are interrelated, at the same time maximal productivity of the technological equipment with minimal specific electric power consumption corresponds to optimal energy mode

Measures for electric power saving by rationalization of the available technology and installation of new technology resolve simultaneously the tasks of increasing the product output and enhancing quality factors of the production It is necessary to note that due to a lack of on-site metering of electric power consumption at the enterprise, it is practically impossible to obtain actual balance of electric power consumption

Therefore, it becomes impossible to determine the electric power expenditures by specific items of revenues and expenditures (for each type of production, lightning, ventilation, transport, losses in the networks, losses in the transformers, etc) and the main objective of the collection and analysis of data related to electric power consumption is a wider scope of rationing as regards electric power consumption, a decrease in the number of the enterprise s divisions where it is impossible to establish standard levels of electric power consumption

Proceeding from the above-said, the top priority task of increased efficiency of electric power consumption is the installation of a complex computerized system of electric power metering at the enterprise which will give a possibility to conduct analysis of the electric power consumption at the enterprise and obtain objective data to make the following decisions

- Optimal load of the equipment installed in specific shops and sections
- Regulation of the enterprise load during peak hours
- Lowering customer contract demand with the control of the consumption during the peak hours, without allowing the demand to exceed the set figure which will allow to exclude the payment of penalties

Availability of commercial metering of electric power consumption will allow the enterprise to register the consumption at night hours and pay for it at a lower tariff (i e a preliminary analysis of the consumption at specific shops and sections will be conducted, optimal modes of work in these divisions and their impact of the total consumption of the enterprise will be identified)

It is interesting that a single technological cycle is not maintained in the operation of practically the whole electric power equipment of the enterprise A lack of rythmical use of the equipment results in irrational losses which decrease energy efficiency of its use

Section 4

Recommended Energy Efficiency Measures

The energy auditors investigated as many potential efficiency measures as possible in the time budgeted for the project Subsequent to this, the most cost-effective measures are recommended for implementation by the enterprise Some of the potential energy efficiency measures are not reasonable because of the long payback period, or very high initial cost Those measures in the recommended list consist of actions that have simple paybacks of less than 3 years Given the economic conditions in Russia, this seems like the most reasonable maximum time period for the measures to be paid for by the savings

A Potential Energy Efficiency Measures

As a result of the study conducted, a number of measures (projects) aimed at lowering power consumption and achieving higher efficiency of the enterprise operation were identified It is necessary to emphasize that the conduction of a detailed power study of the whole enterprise with the preparation of a complete list of recommendations was not the objective of this work At this stage this work is too early and can not be performed due to a lack of statistical information on the flow of power resources of specific (though, major) power consumers This is very true especially for electricity and city water consumption Taking into account local concentration of steam generation and major steam consuming capacities, particular attention was paid to the thermal technical machinery of the enterprise Due to this reason, a list of recommended energy saving measures was prepared for the thermal technical machinery At the same time, the equipment of heating system and hot water supply system installed outside the boiler house was not included into the study

It is evident that the enterprise has sufficiently large potential for energy saving For example, based on our estimation, total saving of heat power at the enterprise (in terms of natural gas consumption) may reach 30-35%

The following steps are recommended to be implemented on a continuing basis to ensure an energy saving policy at the enterprise

1 Organize a large-scale system of energy resources metering (including in its "relation" to the output by specific structural subdivisions of the enterprise)

2 Collect and systematize information energy information of the system

3 Conduct an on-going energy analysis of the enterprise with an obligatory use of the information obtained from the system during the analysis

4 Develop a full list of measures aimed at complex lowering of energy consumption

5 Prepar a program for conducting energy saving policy that consists of certain clearly developed (not only technically, but also economically[1]) stages At the same time all measures should be presented in the order of priority, taking into account a lot of factors

- ☐ Economical expediency of the implementation
- ☐ Term of capital repayment
- ☐ Financial support for the project and a scheme of financing

- Guarantees of reliability - an extent of risk
- Consistency between the project and a long-term strategy for the enterprise development
- Impact made by a possible retooling of the enterprise, changes in the product line etc

The enterprise itself has to do most of the work in this direction in the future

B Recommended Cost-Effective Measures

The recommended cost-effective measures are described in the following pages, together with the estimated energy savings, the costs and the simple payback period

PROJECT 1 The Installation of Computerized System of Complex Energy Resources Metering on the Basis of the Technical Equipment Complex (TEC) "ENERGIA"

The Purpose of the Project Organization of commercial and in-site metering of energy resources consumption

Justification

At the moment the enterprise pays its bills for energy resources consumed in the following way

- Electricity based on the readings of the adders ETSmik-32
- Natural gas based on the readings of the gas meter without any adjustments for temperature and pressure (during the conduction of the study the meter was faulty and all payments were done based on the bills sent by the gas supplier)
- City water based on the readings of the water flow meter

In-site and shop metering of generation and consumption of fuel and energy resources is practically not available

The installation of the system of commercial metering of received energy resources, consumed electricity heat with steam and hot water, city water, compressed air will allow to considerably increase the possibility for analyzing the consumption of fuel and energy resources, make decisions on the optimal load of specific shops and sections, lower customer contract demand for electricity and control its consumption during peak hours without allowing it to exceed the customer contract demand and through this measure exclude payment of penalties

The metering of generation and consumption of steam for technological purposes of the enterprise will allow to conduct analysis of heat consuming units operation, efficiency of their operation, identify places of losses

A flexible software of TEC allows to create a large number of metering groups with a multiple inclusion of any number of channels into them that gives a possibility to develop a more flexible system of data processing

The specialists of OAO "IVELEKTRONALADKA" performed the study to identify an estimated cost of the TEC system "Energia"

It is suggested that the installation of the system be implemented in two stages

The first stage includes designing, costs to purchase major equipment, software, installation and setup of the electric power metering system at the enterprise

32 points of electric power metering have been identified

The completion of works related to the first stage will allow to pay for electricity consumed during night hours at a lower tariff (the ratio is 0 65 in case the connected capacity is more than 750 kVA and it is 0 8 in case the connected capacity is less than 750 kVA)

Estimated costs of the first stage of the system installation is 100 million rubles

The second stage of installation includes the system of metering and monitoring over the following energy resources natural gas, steam for technological purposes and cogeneration, cogeneration water, hot water supply, city water, compressed air

The installation of the natural gas metering point with adjustment for pressure and temperature will allow the enterprise to pay bills to suppliers based on the actual amount of gas used

At the second stage it is planned to install 5 points of steam flow metering points, 10 cogeneration and hot water metering points, one point of city water metering, 3 points of compressed air metering

Estimated costs of the second stage are 85 million rubles

Capital Investments 185 million rubles/ 32 5 thousand $USA

Energy Resources Saving

In world practice computerized systems of metering consumption are not looked upon as direct energy saving measures In modern world it is impossible to conduct reasonable (planned, economically justified, etc) energy saving policy without having complete background information about the facility as a whole, and about its energy consuming subdivisions, in particular Therefore, availability of this system must be looked upon as an obligatory condition for a normal operation of the enterprise At the same time, experience related to the installation of analogous systems at other facilities allows to forecast saving of energy resources by simply organizing elementary metering of consumption at a level of up to 10-20% For example, at the moment it is impossible to separate "day" consumption of electricity from the "night consumption from the point of view of commercial metering At the same time it is impossible to perform analysis of in-site electricity consumption to justify a transfer of specific subdivisions/sectors of the enterprise to a night operation (it is an urgent issue especially for powerful electric furnaces)

During a subsequent analysis of information which the system will collect a development of a policy for lowering energy consumption at the enterprise that would be justified from the technical point of view and, which is more important from the economic point of view will be possible

It is important to note that the system as such does not save energy resources it is an instrument that in skillful hands allows to significantly lower (up to 50% in known cases) energy consumption

As regards this enterprise, we evaluate the efficiency of the system installation (during one year) at the following level

- Electric power up to 5% of total electric power consumption
  (210 thousand kW/h/117 9 million rubles/20 7 thousand $USA)

- Heat power up to 6% of natural gas consumption
  (244 1 tons of reference fuel/213 6 thousand m^3 of gas/ 61 8 million rubles/10 8 thousand $USA)

- Water up to 5% of total consumption
  (10 1 thousand m^3 / 3 2 million rubles/0 6 thousand $USA)

TOTAL, all energy resources 182 9 million rubles/ 32 1 thousand $USA

Period of Capital Repayment (in relative terms) less than a year

PROJECT 2 Rehabilitation of the Thermal Insulation Covering of the Pipelines Boilers Hot Wells, etc.

The Purpose of the Project

Lowering of heat losses into the environment from steam pipelines, exterior surfaces of the boilers, traps, etc

Justification

To calculate losses and evaluate saving obtained, analysis of the conditions of the thermal isolation of the enterprise heat supply system was conducted As a result of a visual survey of the steam distribution system, data on the availability of insulation and its conditions was gathered In accordance with the estimates of the working group, almost 100% of the pipelines do not have insulation Not a single gate and not a single flange available have insulation It is a normal practice for Russia, but heat losses in this case are sufficiently high, especially if we take into account a rather big amount of gates and flanges All analyzed boilers of the enterprise as well as hot wells do not have external thermal insulation In connection with the above-said, there are considerable heat losses in the steam distribution system

Capital Investments

Taking into account a small scope of work to be conducted, we think that it is possible to perform this measure by the enterprise itself without inviting outside companies Therefore, amount of capital investments is estimated at the cost of thermal insulation and amounts to approximately 10 million rubles (1 750 $USA)

Energy Resources Saving

Based on rough estimates, heat losses can be lowered by 500 Gcal/year as a minimum which in the terms of natural gas consumption will amount to 69 4 thousand m^3 of natural gas or 20 million rubles or 3 5 thousand of $USA

Period of Capital Repayment 6 months

PROJECT 3 Installation of Steam Traps in the Steam Consuming Equipment

The Purpose of the Project Lowering heat losses with flying steam at the steam consuming equipment (boilers, dry kilns)

Justification

During the performance of the works aimed at conducting the energy study, a complete lack of steam traps at the steam consuming units was identified Two heating boilers, two boilers of hot water supply and two steam dry kilns of the lumber working shop may be referred to major steam consuming units In the recent past steam was used for technological purposes (washing machines), but its share is small (less than 10%) and is constantly decreasing, as the experts think it can be neglected Not a single unit has a steam trap Not a single boiler is equipped with the indicator showing the level of condensate in the unit In connection with this, certain part of steam is not used in the units and 'flies" through them The situation is aggravated by the fact that the length of the condensate lines from the units to the hot wells is small (it does not exceed 40 m) Flying steam that does not have time to condensate in the condensate lines gets to the hot wells and through their exhausts it gets into the atmosphere A visually powerful steaming at the hot well exhausts is explained by this Based on our estimates, condensate losses (flying steam getting into the atmosphere) reach 35% (data of the study of March 10, 1997) According to the personnel, such large amount of condensate losses may be explained by the fact that during the measuring process a dramage of the condensate into the sewage system took place because of its low quality Nevertheless, it is evident that such losses are not permissible and must be liquidated While evaluating the efficiency of the condensate recovery system operation, we proceeded from the fact that condensate losses were at the level of 10% A breakthrough of the steam and its subsequent 10% loss results in excessive consumption of fuel (tap water at the chemical water treatment T=10°C, steam pressure is 3 5 bars) at the level of 25%

Requirement in steam traps

- ☐ Pressure of 3 5 bars, diameter 2" 1 vertical + 4 horizontal
- ☐ Pressure of 3 5 bars, diameter 1' 1 horizontal

Capital Investments

Amount of capital investments amount to the cost of purchased equipment and is estimated at the level of 11 4 million rubles (2000 $USA)

Energy Resources Saving

Based on estimations, annual heat losses may be reduced in the terms of natural gas consumption by 25%, or by 890 thousand m^3/year which in the current prices for gas is 257 million rubles, or 45 1 thousand $USA

Period of Capital Repayment less than one month

PROJECT 4 Inspection of Stop Valves

The Purpose of the Project Determination of Condition of Stop Valves of Thermal Technical Equipment with the Aim of Finding Defects and Replacing the Valves

Justification

During the performance of the survey in June 25, 1997, it was found out that the stop valves in the line of steam supply to the dry kiln of the lumber working shop did not close tightly The diagnostics works were conducted with the help of the ultrasonic device "ULTRAPROBE-500", which is a multipurpose device used to identify leaks in stop valves as well

Based on our estimates, in order to conduct a large-scale inspection of all thermal technical equipment of the enterprise, it is necessary to use the services of specialized firms that have diagnostics equipment Estimated labor costs are as follows one specialist with a device is to work during one full working day

Capital Investments

1 14 million rubles (200 $USA) as a maximum

Energy Resources Saving

The inspection as such will not result in energy saving effect Nevertheless, based on its results, it will be possible to develop a program for repairing/replacing stop valves, the implementation of which will allow to liquidate non-production consumption of heat power

Period of Capital Repayment -

PROJECT 5 Higher Efficiency of Combustion during the Equipment Operation

The Purpose of the Project Lowering Heat Losses that Result from a Lack of Control Instrumentation to Check the Boiler Unit Operation

Justification

Boilers operation is conducted manually by changing gas and air pressures before the burners Gas-air ratio before the burners is maintained in accordance with the mode charts of the boilers, but air pressure devices have such ranges and resolution that do not allow the operating personnel to maintain the mode in accordance with the mode chart For example, in case of a maximal load of the boiler DKVR 2 5/13 an optimal air pressure before the burners did not exceed 20 mm of water while the range of the measuring device was 0-400 mm of water

Capital Investments

The maintenance of the optimal gas-air ratio during the operation can take place if the boilers are equipped with control instrumentation that is consistent with the operating ranges of measuring air pressure before the burners

Estimated capital investments amount to 300 $USA per each boiler or the total amount of investments for the boiler house is 5 13 million rubles (900 $USA)

Energy Resources Saving

The potential savings are 0 5-1% which is tantamount to the saving of 35 6 thousand m^3/year of natural gas, or 10 4 million rubles/year (1 8 thousand $USA)

Period of Capital Repayment 6 months

PROJECT 6 Higher Efficiency of Combustion due to Periodical Control of the Combustion Mode with the Help of the Portable Gas Combustion Analyzer

The Purpose of the Project

Lowering Heat Losses that Result from Changes in the Characteristics of Boiler Units in the Operation and Inaccurate Preparation of the Operation Charts Availability of the device gives the personnel the possibility to make diagnostics of the boilers and take timely measures to liquidate defects

Justification

It was established that due to available suctions of air along the path as well as due to inefficient combustion modes, at the moment the content of oxygen in the waste gases is 11 1% for boiler DKVR 2 5/13 # 2758 and 7 8% for boiler DKVR 6 5/13 # 4898 for tested combustion modes During the testing of the combustion modes, we managed to lower the content of oxygen to the level of 7 6% and 4 9% respectively only by adjusting the optimal gas-air ratio for the current mode Losses with waste gases q_2 lowered from 8 9% and 6 1% to 6 2% and 4 8% respectively

Control of the boilers is done manually, there are no devices for automatic regulation of combustion During the operation of the boilers in the manual mode, the personnel uses the mode charts If gas combustion analytical devices are available the personnel can independently and periodically adjust the optimal mode of combustion (for example, in case of changes in the characteristics of the boiler during the operation) and conduct diagnostics of the boilers

Capital Investments

The purchase of a portable multicompoment analyzer (O_2, CO, NO, t, efficiency) that is 3000 $USA is suggested for the boiler house

Capital investments amount to 22 23 million rubles (3900 $USA)

Energy Resources Saving

Estimated potential for saving is up to 1% which is tantamount to the saving of 35 6 thousand m^3/year of natural gas, or 10 3 million rubles/year (1 8 thousand $USA)

Period of Capital Repayment Two years and two months

PROJECT 7 Inspection of Air Ducts and Stop Valves with the Installation of Stop Valves in Major Air Ducts

The Purpose of the Project

Lowering losses in the lines of compressed air transportation for non-production purposes

Justification

Energy consumption of the compressor station is significant and amounted to 620000 kWh in 1996

During the visit of the enterprise in April 4, 1996 there were compressed air leaks identified The largest of them (by ear) was identified in the air supply line (SRMP) The personnel reacted to the leakage calmly, apparently, such cases are frequent at the enterprise Strictly speaking, leaks within 20% can be considered standard Nevertheless, it is necessary to conduct a planned struggle to reduce them to the minimum

In addition to this, due to the fact that the enterprise is constantly developing and the product line is undergoing changes (for example, former compressed air consumers disappear, and new consumers appear), it is worth installing stop valves in each main compressed air supply line connected to each consumer group It will allow to cut off idle equipment and by doing this, firstly, to liquidate direct leakage in cut off lines/mechanisms, secondly, to decrease amount of the air system that will lower the load of the compressor station

Capital investments

The following includes the inspection of the compressed air lines and stop valves firstly, diagnostics of airtightness, secondly, the liquidation of defects identified Diagnostics may be conducted with the help of the ultrasonic device ULTRAPROBE-200 that is available in specialized companies The work may be performed during one working day We estimate the cost of the work done by one specialist with the device at the level of

1 1 million rubles (200 $US)[3]

The cost of stop valves is estimated as

1 million rubles (175 $US)

Liquidation of identified defects and the installation of stop valves may be conducted by the specialists of the enterprise itself

Therefore, total capital investments will amount to 2 1 million rubles (375 $US)

Energy Resources Saving

[3]It is necessary to bear in mind that project #4 provides for the inspection of pipelines stov valves of the thermal technical equipment of the enterprise Given a small size of the enterprise the work may be combined We think that it is possible to perfom work on both projects during one working day

It is possible to adopt the potential of savings at the level of 5% of electric power consumed by the compressor station in 1996, i e

31 thousand kW/h per year, of 17 4 million rubles/year (3 0 $US)

Period of Capital Repayment Less than two months

Section 5

Appendix

This appendix contains data and information collected during the on-site activities that was used in the development of the recommended efficiency measures

Tables 1-3 Consolidated Tables of Product Output in 1994 1995 1996

CONSOLIDATED TABLE OF AO RIAT PRODUCT OUTPUT IN 1994

Item	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	TOTAL
Bus	3	0	7	2	4	1	0	0	0	0	0	0	17
Engine GAZ-52	117	73	170	30	30	85	50	56	90	80	80	90	951
Engine GAZ-53	124	93	200	78	74	120	23	86	140	150	110	127	1 325
KPP	124	17	130	17	57	100	20	60	86	85	80	80	856
Water pump 4022	11 525	15 111	16 000	21 000	18 000	18 090	18 523	21 000	15 000	17 000	20 000	20 000	211 249
Oil oump G-53	0	0	0	0	0	0	0	93	100	102	100	100	495
Water pump 4062	6	0	41	40	0	0	107	87	101	100	100	1000	682
Water pump 24	760	0	1000	0	611	1000	0	44	2048	2336	1002	100	9 801
Valve socket 4022-33	72 000	84 000	84 000	84 000	72 000	84 000	60 000	48 000	12 000	0	24 000	57 700	681 700
Valve socket 4022-38	72 000	84 000	84 000	84 000	72 000	84 000	60 000	48 000	0	0	24 000	55 200	667 200
Valve socket 406 30	0	0	64	64	0	0	400	4000	2000	2000	2000	0	10 528
Socket 13-1007038	12 000	11 000	11 000	0	0	0	0	0	0	0	0	0	34 000
Socket 66-1007038	27 000	0	0	0	0	0	0	0	0	0	0	0	27 000
Clutch G-24	8 386	9 953	13 000	13 176	9 284	12 029	10 533	12 012	12 000	14 202	15 882	16 796	147 273
Cranked shaft G-53	48	1 300	826	992	950	1 107	371	1 085	1000	960	342	422	9 403
Cranked shaft G-24	706	69	382	0	10	0	800	0	0	92	180	10	2 249
Clutch disk G-53	1 250	0	2000	900	1 400	1 900	100	2 100	3000	3000	3000	2 100	20 750
Clutch disk UAZ	0	0	0	0	0	0	0	0	0	0	490	0	490
Lining of the g/unit	1 780	0	2000	4000	1 040	1 500	0	2000	260	2000	2000	1000	17 580

Water pump ZMZ-53	0	0	0	0	0	0	0	2	100	47	280	300	729
W pump lining ZMZ-53	0	0	0	0	0	0	0	0	0	20	100	0	120
Cap valve lining	0	0	0	0	0	0	0	0	200	420	500	300	1 420
Lining for tr ZMZ	0	0	0	0	0	0	0	0	100	210	250	400	960
UAZ barrel linining	0	0	0	0	0	0	0	0	0	0	0	0	-
Cat ladder	170	100	200	0	160	0	0	0	0	0	0	0	630
Garage	16	3	30	0	20	28	0	15	0	0	0	0	112

CONSOLIDATED TABLE OF AO RIAT PRODUCT OUTPUT IN 1995

Item	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	TOTAL
Engine GAZ-52	102	7	11	0	8	0	0	0	0	0	20	17	165
Engine GAZ-53	80	90	60	4	55	55	0	40	47	50	50	50	581
KPP	70	50	35	0	30	0	0	30	20	0	0	0	235
Water pump 4022	18 910	17 000	17 118	20 000	19 000	17 700	19 410	19 000	20 495	20 915	23 270	26 712	239 530
Water pump 4061	26	126	170	150	450	500	500	596	0	0	0	0	2 518
Water pump 4062	394	474	321	50	350	200	600	575	0	234	250	1055	4 494
Water pump 24	475	366	260	400	500	120	0	400	0	358	230	570	3 679
Valve socket 4022-33	48 000	84 000	84 000	84 000	60 000	84 000	108000	66 000	66 000	90 000	84 000	96 000	954 000
Valve socket 4022-38	84 000	36 000	60 000	60 000	60 000	72 000	96 000	90 000	75 000	66 000	82 000	84 000	805 000
Valve socket 406-30	17 000	12 000	12 000	7000	11 000	12 000	18 000	20 000	19 000	18 000	13 000	27 000	186 000
Clutch G-24	11 565	10 617	17 235	18 456	19 000	19 000	19 000	19 000	19 000	19 000	20 000	20 000	211 873
Cranked shaft G-53	644	420	600	798	560	441	350	462	604	267	210	400	5 756

Cranked shaft G-24	354	420	190	155	350	287	364	448	251	392	201	213	3 625
Clutch disk G-53	250	0	400	1 400	1000	1000	250	1 640	1 150	700	380	100	8 270
Clutch disk UAZ	0	0	0	500	300	28	0	213	480	300	432	400	2 653
Lining of the g/unit	595	404	1 800	1 600	2 005	1 290	0	1 690	1 925	700	0	350	12 359
Water pump ZMZ-53	350	400	400	450	395	400	0	400	400	400	350	400	4 345
W pump lining ZMZ-53	200	400	420	500	500	400	0	700	700	700	350	400	5 270
Cap valve lining	300	0	0	0	0	100	0	0	150	50	200	300	1 100
Lining for tr ZMZ	200	0	0	100	150	250	0	0	250	150	200	300	1 600
UAZ barrel linining	100	0	0	0	100	200	0	0	0	0	0	0	400

CONSOLIDATED TABLE OF AO RIAT PRODUCT OUTPUT IN 1996

Item	I	II	III	IV	V	VI	VII	VII	IX	X	XI	XII	TOTAL
Engine GAZ-52	79	90	95	90	75	85	0	65	60	60	67	50	816
Engine GAZ-53	130	140	130	115	95	121	0	85	80	80	80	80	1 136
KPP	75	65	70	65	38	65	0	45	40	40	40	40	583
Water pump 4022	23 378	17 996	22 001	20 775	17 225	20 135	19 000	20 006	15 590	16 110	17 810	19 620	229 646
Water pump 4061	0	0	0	0	0	0	0	0	0	0	20	30	50
Water pump 4062	116	318	306	350	169	300	150	310	300	80	280	650	3 329
Water pump 24	1000	1000	1 100	1000	441	0	0	500	400	120	450	198	6 209
Valve socket 4022-33	105200	108000	95 400	54 500	84 000	108000	60 000	36 000	36 100	84 000	96 100	96 000	963 300
Valve socket 4022-38	55 000	48 000	164600	161500	72 000	90 600	0	12 000	36 100	96 000	108100	108000	891 900
Valve socket 406-30	4000	4000	7000	4000	3000	5000	0	9000	5000	8000	6000	7000	62 000

Clutch G-24	19 544	18 016	19 500	16 500	15 000	18 000	18 000	18 000	17 000	17 834	18 000	14 238	209 632
Cranked shaft G-53	693	468	514	812	428	668	119	817	745	763	712	422	7 161
Cranked shaft G 24	335	129	172	224	196	336	115	387	376	364	420	756	3 810
Clutch disk G-53	2 250	2000	2000	1 500	900	500	0	1600	1000	700	1 600	0	14 050
Clutch disk UAZ	300	300	250	250	200	300	0	400	700	360	400	200	3 660
Lining of the g/unit	2000	2000	2 800	2 500	2 100	1 200	0	1544	200	2000	1000	1009	18 353
Water pump ZMZ-53	305	300	350	350	300	350	0	350	350	350	350	350	3 705
W pump lining ZMZ-53	200	200	200	200	200	200	0	300	150	0	0	0	1 650
Cap valve lining	800	200	200	400	200	300	0	300	300	300	300	400	3 700
Lining for tr ZMZ	0	400	400	400	400	200	0	275	200	100	150	0	2 525
UAZ barrel linining	0	0	100	100	100	100	0	100	75	0	100	200	875

Table 4 Results of Changes in the Flue gases Content in Boiler DKVr-6 5/13 # 4898 Fuel-Natural Gas The Boiler House of AO RIAT

#	Parameter	Item	Unit	Load 5 4 tons/hour			
				chart mode	photography	1	2
1	Gas pressure in the cylinder	Pc	kgf/m^2	4 5			
2	Gas pressures before the burners	Pg	kgf/m^2	70			
3	Air pressure before the burners	Ha	kgf/m^2	16	16		
4	Air temperature before the burners	Ta	°C	22	18		
3	Discharging in the furnace	Sf	kgf/m^2	2 5			
4	Content in waste gases behind the boiler						
	oxygen	O_2	%	5 3	6 3	4 8	4 2
	carbon dioxide	CO_2	%	8 8	8 2	9 0	9 3
	carbon oxide	CO	$\%x10^{-4}$	0	3	0	37
	nitrogen oxide	No_x	$\%x10^{-4}$		83	73	72
5	Content in waste gas behind the economizer						
	oxygen	O_2	%	6 8	7 0	6 0	4 9
	carbon dioxide	CO_2	%	8 0	7 7	8 4	9 0
	carbon oxide	CO	$5x10^{-4}$	0	2	4	27
	nitrogen oxide	NO_x	$\%x10^{-4}$		75	71	70
6	Temperature of waste gases behind boiler	Twg	°C	230	222	213	213
7	Temperature of waste gases behind the economizer	Twg	°C	125	124	111	113
8	Temperature of feed water before the economizer	Tfw	°C	65-70	40	42	40
9	Temperature of feed water behind the economizer	Tfw	°C	85-95	88	84	80
10	Air surplus factor						
	behind the boiler	a_b		1 3	1 4	1 27	1 23
	behind economizer	a_e		1 43	1 5	1 35	1 28
11	Heat losses with waste gases	q_3	%	6 02	6 1	5 0	4 8

12	Heat losses in the ambient air	q_5	%	2 65			
13	Gross efficiency of the boiler unit	η_b	%	91 33	91 25	92 35	92 5

Table 5 Results of Changes in the Flue gases Content in Boiler DKVr-2 5 13 rg # 2758 Fuel-Natural Gas The Boiler House of AO RIAT

#	Parameter	Item	Unit	Load 3 25 tons/hour			
				chart mode	photography	1	2
1	Gas pressure in the cylinder	Pc	Kgf/m^2	4 5			
2	Air pressure before the burners	Ha	Kgf/m^2	17	19	13	9
3	Air temperature before the burners	Ta	°C	22	23		
4	Discharging in the furnace	Sf	Kgf/m^2	2 5			
5	Content in waste gases behind the economizer						
	oxygen	O_2	%	7 1	11 1	8 5	7 6
	carbon dioxide	CO_2	%	7 8	5 4	6 9	7 4
	carbon oxide	CO	$\%x10^{-4}$	0	0	5	290
	nitrogen oxide	NO_X	$\%x10^{-4}$		46	81	79
6	Temperature of waste gases behind the boiler	Twg	°C	140	154	149	147
7	Temperature of feed water before the economizer	Tfw	°C	65-70			
9	Temperature of feed water behind the economizer	Tfw	°C	85-95	88	84	80
10	Air surplus factor behind economizer	a_e		1 46	2 05	1 62	1 52
11	Heat losses with waste gases	q_3	%	6 99	8 9	5 8	6 2
12	Heat losses in the ambient air	q_5	%	2 69			
13	Gross efficiency of the boiler unit	η_b	%	90 3	88 4	90 5	90 9