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ENERGY EFFICIENCY AUDIT REPORT
SLOKAS PULP & PAPER FACTORY
JURMALA, LATVIA

JULY 1992

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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 in Latvia and not an exhaustive engineering analysis. RCG/Hagler, Bailly, 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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Mrs. Larisa Auns	Chief Economist/Economics Director
Mr. Jevgenijs Ivanovs	Chief Energetics
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FINAL ENERGY AUDIT
SLOKAS CELULOZES UN PAPIRA FABRIKA
(Sloka Pulp & Paper Factory)
JURMALA, LATVIA

BY
RCG/HAGLER, BAILLY, INC.
B.V. EKODOMA, LTD.
RIGA TECHNICAL UNIVERSITY

JULY 1992

I. EXECUTIVE SUMMARY

A team of engineers from RCG/Hagler, Bailly, Inc., B.V. Ekodoma, and Riga Technical University carried out site activities at Slokas Celulozes un Papira Fabrika (SCPF, Sloka Pulp and Paper Factory) from December 9-11, 1991 to work together with SCPF staff to identify and implement improvements to energy efficiency.

Based on energy consumption in 1991 and European market energy prices prevailing at the time of the visit[1], the total economic cost to the economy of Latvia for the energy plan for 1992 at SCPF is estimated as $12 million. The actual cost may be less, if Latvia succeeds in obtaining fuels and electricity at prices lower that the European market. The primary energy forms used at SCPF are natural gas and electricity, and the total economic energy costs for 1992 at SCPF are estimated as follows:

natural gas:
70 million m^3 per year, or 2.4 PJ/yr[2]
(56,000 tons oil equivalent per year)
at an economic value of $7.1 million per year
purchased electric power:
19 MW peak demand,
at an economic value of $1.1 million per year
purchased electric energy:

---

[1] Energy prices in Latvia at the time of the visit were increasing rapidly, but were still far below European prices, reflecting a transition from the historical energy price subsidies provided in the Soviet Union.

[2] 1 PJ = 1 X 10^{15} joules, 2.4 PJ = 570 Tcal

80,000 MWh/yr,
at an economic value of $4.0 million per year.

RCG/Hagler, Bailly estimates the potential for energy efficiency improvement at SCPF as about 15-25% without process changes, at current production levels. During the survey, the RCG/Hagler, Bailly team worked together with SCPF staff to identify short-term, low-cost energy efficiency projects, which, if implemented, will achieve economic benefits of $1.7 million per year, or 14% of 1992 economic energy costs.

In addition, RCG/Hagler, Bailly evaluated a short-term, low-cost productivity improvement project which would provide additional net economic benefits of $3.51 million per year and would improve energy efficiency (reduce energy consumption per ton of paper) at SCPF by a further 7%.

The recommendations and expected results are summarized in Exhibit 1.

RCG/Hagler, Bailly recommended that SCPF receive a package of equipment from USAID, and USAID agreed. The procurement list and budget for SCPF, as approved by USAID, is summarized in Exhibit 2.

EXHIBIT 1
SLOKAS CELULOZES UN PAPIRA FABRIKA

SLOKA PULP & PAPER FACTORY

Summary of energy efficiency projects

	Natural Gas	Electricity		Cost/Value	
	Km^3/yr	MW	MWh/yr	MRbl/yr	MUS$/yr
BASE CASE	70,000	19	80,000	140	$12.00

RECOMMENDATIONS AND ESTIMATED ECONOMIC BENEFITS:

	Natural Gas	Electricity		Benefits[3]
	Km^3/yr	MW	MWh/yr	US$/yr
A. General & Energy Management				
A.1 Increase production	(7,000)	0	(11,400)	$3,510,000
A.2 Energy management	1,400		1,600	219,000
A.3 Efficiency teams	3,500	1.0	4,000	567,000
A.4 Boiler combustion	2,100			216,000
A.5 Electric generation	(7,200)	3.5	21,000	530,000
A.6 Water treatment	140			12,000
B. Short-term, Low-cost Efficiency Improvements				
B.1 Humidity sensors	1,400			144,000
B.2 Steam traps	350			36,000
Summary of all projects:				
TOTAL SAVINGS/BENEFITS	(5,310)	4.5	15,200	$5,234,000
Percent improvement	-8%	23%	19%	43%

[3] Benefits are net annual benefits of energy savings and productivity improvement, not including quality improvements.

Energy saving projects only (not including Recommendation A.1):

TOTAL SAVINGS	1,690	4.5	26,600	$1,724,000
Percent improvement	2%	23%	33%	14%

EXHIBIT 2
AID EMERGENCY ENERGY PROGRAM FOR EASTERN EUROPE
LATVIA INDUSTRIAL ENERGY EFFICIENCY

PRELIMINARY PLANS FOR PROCUREMENT

SLOKAS CELULOZES UN PAPIRA FABRIKA
SLOKA PULP & PAPER FACTORY

	Estimated Procurement Budget
Fixed humidity sensors for paper drying machines	$18,000
Lotus 1-2-3 software	500
Electronic combustion analyzer	5,000
Boiler water dissolved solids meter	500
Electric survey meter (with power factor)	1,200
Ultrasonic tester for steam traps/compressed air	4,000
Steam traps (30)	6,000
Total	$35,000

II. INTRODUCTION

2.1 Plant Description

The Sloka Pulp and Paper Factory (SCPF) is located in the small town of Sloka (now consolidated into the city of Jurmala), some 50 km to the west of Riga in the Republic of Latvia. The plant was originally constructed as a private venture in 1864. It produces a wide range of paper products plus some ancillary chemicals, such as lignosulfate, as byproducts. The plant cogenerates about a third of its own electricity and provides hot water to the town of Sloka for town heating. About 2,700 workers are employed at the plant. Energy costs represent about 20% of SCPF's direct manufacturing cost.

SCPF had its last large reconstruction/modernization in 1960-64, which makes the plant old by paper industry standards. In 1964, SCPF installed paper machine #7, which is 2400 mm wide and uses Dutch technology at a capacity of 18,000 ton/yr. In 1965, SCPF installed paper machine #8, which is 4200 mm wide and uses Finnish technology, at a capacity of 50,000 ton/yr. These are their most modern machines but they have other, older ones.

In 1975, SCPF installed a new pulp mill producing 70,000 ton/yr. In 1975, SCPF installed waste water treatment plant, including secondary treatment (using aerobic activated sludge process) which also serves city of Jurmala. In 1975, SCPF started to use black liquor to make lignosulfate at 50% moisture content, which they send to Russia as a product for metallurgy. It is not possible to use a black liquor boiler at this site because of SO2 concerns - plant is located in heart of the summer tourist area at Jurmala, which is an ecological protection zone.

Until 1986, SCPF were operating a thermal electric station burning dried, pulverized peat (with substantial flyash emissions). They converted their smaller boilers to gas at that time, but have since been short of electricity so they are now buying from the Latvenergo grid.

In 1988, SCPF became the first enterprise to be owned by the Republic of Latvia; most other large enterprises became Latvian only in 1991. Since 1988, SCPF has had a continual battle with environmental activists who want to close the factory because of the nearby resorts. However, by demonstrating that the plant uses the same pollution control technology as found in Sweden and Finland, SCPF has been able to maintain operations, albeit at a reduced rate.

In 1991, SCPF started a new joint venture with Spanish firm for the manufacture of wallpaper, a high quality product.

Pulp production

Of SCPF's pulp capacity of 70,000 t/yr, they are now producing only 40,000 t/yr. This turndown is mainly for ecological reasons, because they have no buyer for the waste lignosulfate produced, which is 65,000 t/yr @ 50% m.c.. Importing 22,000 t/yr pulp from Russia.

Paper production

SCPF produces 20 types of paper, 80,000 t/yr. SCPF produces cardboard, ice cream containers, wallpaper, and some newsprint. SCPF imports sulfur, Na_2CO_3, chlorine, and other raw materials from Russia. About 30% of the production is sold in Latvia, rest for Baltics and to the East. SCPF is exporting the wallpaper to the West, and have plans with Finland for joint venture to make carton and coated paper. SCPF has fermentation and distillery for wood alcohol for industry and medical, making 1.5 million liters per year. SCPF is planning to privatize as a stock company, but Government has not given the command yet.

Pulp & paper is one of the leading industries in the Scandinavian countries, and has strong growth potential in the Baltics. Latvia has plans to double (or 2.5) capacity in paper production in several phases, will require $600 million. Because of the environmental concerns, the probable site for the facility would be somewhere else (Ventspils or Leipaia), but it may be part os the SCPF company so that technological expertise to available. The preliminary estimate for the budget for the first phase of this expansion is $150 million.

Energy consumption

Gas: Natural gas consumption in 1991 was 71 million m^3, with 88 million m^3 planned for 1992 because of the wallpaper expansion.

Electricity: In 1990, SCPF generated 44 million kWh on-site and purchased 77 million kWh from Latvenergo (total 121 million kWh). For 1991 total electric consumption is estimated as 119 million kWh, and the plan for 1992 is 147 million kWh (54.5 self-generated). Peak demand at SCPF is about 19 MW.

Steam Generation

Sloka uses four boilers for steam generation as follows:

Steam pressure: 40 bar

Steam temperature:	440 C
Design capacity:	#5: 35 t/hr
	#6, #7, #8: 75 t/hr each

Boilers are of similar design, equipped with economizers and air preheaters, and 4 or 6 natural gas burners. Boiler #7 has fuel oil capability. In normal winter conditions as observed during the visit, two boilers operate, each at about 60% load. Gas flow is maintained essentially constant, limited by the restrictions imposed by the gas company. Fuel oil is not burned due to pollution restrictions in the area around the plant.

All boilers have continuous blowdown with heat recovery; boiler water analysis and adjustment of blowdown is performed once each shift. A major part of the combustion air is taken from the ceiling level of the boiler room, and mixed with outside air in the ducting below the boiler.

Aside from the boiler water level and safety controls, all control of the boilers is performed manually. Fuel is varied to maintain boiler pressure, except when near the demand limit, when fuel remains constant and boiler pressure is allowed to drop slightly.

Fuel flow, makeup water, and steam flow are metered on each boiler and monitored on strip chart recorders. Hourly logs of the main parameters are maintained. Unfortunately, flow measurements do not appear to be reliable: a quick check of measured steam and gas flows resulted in a boiler efficiency of 99%. Stack temperature measurements before and after each economizer and air preheater bank appear to be reliable. The originally installed exhaust O2 meter does not function. An empirically developed nomograph identifies the combustion air pressure to optimize the fuel-air ratio (minimum excess air) at varying loads; however, this nomograph is based on only three operating loads, and is in any case not carefully adhered to.

Electricity Generation

Sloka generates just under 33% of its electricity consumption. One turbine is of the condensing type with a 5 bar extraction; the other is a 5 bar backpressure turbine with a 10 bar extraction. The characteristics of its turbine generators are given below:

Turbine generator	1	2
Maximum power:	6000 kW	6000 kW
Inlet steam pressure:	39 bar	39 bar
Inlet steam temperature:	440 C	440 C

Maximum inlet flow:	56 t/h	81 t/h
Extraction pressure:	5 bar	10 bar
Maximum extraction flow:	40 t/h	50 t/h
Exhaust pressure:	0.05? bar	5 bar
Maximum exhaust flow:	26 t/h	64 t/h
Minimum exhaust flow:	16 t/h	31 t/h

Typical winter operation during 1991 as found during the audit was that only Turbine 2 was operating: due to the gas limitation there was not enough steam generated to warrant operating a second turbine. The Turbine 2 operation was significantly below the design rating: with an 80 t/h flow into the turbine, and a 20-25 t/h extraction at 10 bar, the turbine output was only just over 4000 kW (under rated conditions, it should approach 6000 kW).

Steam Distribution

Steam is distributed at 3 different pressure levels to various parts of the factory:

- 36-39 bar steam generated by the boilers, going essentially to the turbines (average 120 t/h), but also occasionally to process via pressure reduction valves

- 10 bar steam to the cellulose boiling, lignosulfate plant, and mazout tanks for heating (average 15-17 t/h); available from Turbine 2 extraction, or a pressure reduction valve from the high pressure steam

- 5 bar steam distributed for various uses throughout the plant, including a district heating system for local dwellings (total average use is 90-100 t/h); available from outlet of backpressure Turbine 2, or as extraction from condensing Turbine 1.

Steam meters are originally installed at the four important stations, but because of unreliable operation, a full steam balance could not be obtained. Following are sample data measured during the audit (11 Dec 1991, 14:45):

- 10 bar extraction, Turbine 2: measured 30 t/h (known consumption is less than 20 t/h according to plant staff)

- 5 bar exhaust, Turbine 2: measured 60 t/h

- Turbine 2 inlet: 83-84 t/h (design flow is 81 t/h; sum of extraction and exhaust is 90 t/h)

- Turbine 2 generator output: 5600 kW (design rating is 6000 kW at zero extraction and 64 t/h backpressure flow)

- 40 bar/5 bar pressure reduction valve: flow varying, 12-25 t/h (accuracy of instantaneous measurement is questionable; cumulative counter is out of order).

No meters are available for individual uses of 5 bar steam, except for the district heating system.

District Heating System

An average of 20 t/h 5 bar steam is utilized in the heat exchangers to generate hot water for district heat. The temperature of the outlet hot water is automatically controlled, ranging from 65 C when the outside temperature is +5 C, to 95 C when the outside temperature drops to -20 C. Neither flow nor heat value of the outgoing hot water is monitored. Approximately 12 m3/h makeup water is required due to leaks in the system.

Throughout the central plant, the steam distribution system appears to be in good condition. There are a few minor leaks. Insulation is installed throughout, except on valves and flanges, but needs maintenance.

2.2 Energy Audit Activities

A team of senior engineers from RCG/Hagler, Bailly, Inc., B.V. Ekodoma, and Riga Technical University visited Slokas Celulozes un Papira Fabrika (SCPF) pulp and paper factor November 25 and December 9-11, 1991 to work together with SCPF staff to identify and implement improvements to energy efficiency, a preliminary energy audit. The project managers for the effort were Mr. Gunars Dankfelds, Chief Engineer-Technical Director of SCPF, and Mrs. Larisa Auns, Chief Economist-Economics Director of SCPF. They were assisted by Mr. Jevgenijs Ivanovs, Chief Energetics, and Mrs. Raisa Andrejenev, Energetics Engineer.

The RCG/Hagler, Bailly audit team of engineers consisted of:
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President and Project Manager
Dr. Ivars Veidenbergs, B.V. Ekodoma,
Vice President and Associate Project Manager
Dr. Janis Bazhbauers, Riga Technical University,
Dean of Thermal Engineering Faculty, Project Advisor

Based on initial observations and discussions with management, and following a brief seminar on energy audit techniques and portable energy efficiency instrumentation, the RCG/Hagler, Bailly audit team focused their efforts in the short time available on plant management, information systems, combustion systems, operation of the power station, and process equipment. Two groups were formed from the audit team - a plant management review group and a thermal energy audit group.

A primary focus of the audit was an attempt to achieve immediate energy savings through the use of portable instruments. For this purpose, RCG/Hagler, Bailly's digital combustion analyzer (which measures O2, CO, CO2, unburned hydrocarbon combustibles (HC)) was used, together with a laptop personal computer, using software developed by RCG/Hagler, Bailly which calculates combustion efficiency from these measurements, on the basis of the chemical equations of combustion (molal basis). Tests were also carried out of electric motor efficiency and power factor (cos phi).

The RCG/Hagler, Bailly team presented its recommendations and draft summary report to the Directors of SCPF at the final review meeting December 11, 1991. At this meeting, RCG/Hagler, Bailly recommended, and SCPF agreed, that humidity sensors for the paper dryers, steam traps, and portable instruments should be considered for procurement under the USAID emergency energy program, so that SCPF will be able to achieve maximum energy cost savings from the limited funds available under the program.

The RCG/Hagler, Bailly team observed that the SCPF facilities are at or near a world standard in terms of environmental control for pulp and paper plants. Improved energy efficiency can reduce airborne emissions slightly. It is unfortunate that SCPF is located near a tourist and recreational area, but in the near term the value added by the SCPF plant is critically needed to assist the economic development of Latvia. In fact, RCG/Hagler, Bailly recommends that serious consideration be given to allowing SCPF to burn mazout (Heavy fuel oil) during times of gas shortage, especially in the winter when resorts are closed. In this way, maximum economic efficiency can be obtained since production can be increased, with very little additional energy consumption. If environmental considerations dictate that

mazout combustion is not possible, then consideration should be made of burning light oil (diesel or kerosene, or low-sulfur heavy oil) instead of mazout.

The standard of management and engineering expertise already in place at SCPF is very good. Technical staff is very knowledgeable about energy conservation in general, especially in relation to their process. The RCG/Hagler, Bailly team expects that this staff, with a market-driven focus, and a few additional instruments, tools, and equipment, will be fully capable of making significant improvements to energy efficiency. The staff of SCPF have already begun adapting to market conditions.

The RCG/Hagler, Bailly team would like to express their sincere appreciation for the extraordinary openness and assistance, willingness to accept recommendations and change operating procedures, and warm hospitality offered by the staff of SCPF. It is only because of their openness and cooperation that this effort was possible. The American members of the RCG/Hagler, Bailly team is glad to have had the opportunity to become friends with the staff of SCPF, and hopes to return their hospitality at some time in the future, whenever SCPF staff visit the United States.

III. ENERGY CONSUMPTION ANALYSIS

A graphical presentation prepared by RCG/Hagler, Bailly of basic data received from SCPF on energy consumption, production, specific energy consumption, and other key parameters is attached as Appendix 1. Monthly production and energy data were provided by SCPF for January 1988 - November 1991 and daily data for November 1991.

These graphs are provided for use by SCPF in identifying variations in energy efficiency. The analysis is a tool to point the way for more detailed investigations. These detailed investigations are beyond the scope of the current study, but several points are evident from the analysis. The main points arising from the analysis which were used to develop specific recommendations are as follows:

Monthly paper production at SCPF declined from 1988 to 1990, and has held steady since 1990, at about 40% below the 1988 level. With such a reduction, the energy efficiency of any factory will be reduced, because the fixed energy consumption is spread over fewer units of production.

Monthly energy consumption since 1988 has also declined, by about 25% for gas, 27% for electricity, 36% for water, 13% for compressed air, and 27% for steam.

Monthly electricity generation at SCPF has declined by 47% since 1988. As a result, electricity purchased from Latvenergo is now back up to the same average monthly level as in 1988.

Monthly energy intensity, or specific energy consumption, is a primary measure of efficiency, calculated as the ratio of energy to production, in units such as kcal/kg or kWh/kg. The trends at SCPF are toward higher energy intensity (reduced efficiency), as follows:

	1988	1991
Gas, kcal/kg		
Average	7.2	9.0
Range	6.2-8.5	6.6-10.2
Electric, kWh/kg		
Average	1.4	1.8
Range	1.38-1.50	1.62-2.10
Steam, ton/ton		
Average	9.5	11
Range	8.2-11.1	8.0-13.0

Monthly energy efficiency, or conversion ratio of energy transformation equipment, is measured by the ratio of energy output to energy input. The trends at SCPF show reductions in efficiency, as follows:

	1988	1991
Steam/gas, ton/Mcal		
Average	1.3	1.2
Range	1.24-1.40	1.06-1.29
Electric/steam, kWh/ton		
Average	66	45
Range	58-70	36-61

With increasing energy prices, energy costs at SCPF have escalated substantially, from about 320,000 Rubles per month in 1988-89 to more than 1 million Rubles in November 1991.

Monthly energy/production relationships were analyzed for 1988-1991. Using monthly (lumped parameter) data, there should be a good correlation between energy and production. This analysis can be used to indicate the fixed energy consumption (constant amount per month) and the variable energy consumption (additional amount which is related to production). High fixed energy consumption indicates high energy losses in the plant.

Energy usage should be well correlated with production, as indicated by the results of a regression analysis. In such a regression analysis, RCG/Hagler, Bailly, Inc. analyzes the correlation between energy consumption and the physical production processes which constitute energy demand. In SCPF, two types of energy are used, fuel energy consumption in the form of natural gas, and electricity. The amount of

energy consumed in any given period (dependent variable) should be correlated to the production achieved during the same period (the independent variables).

Several separate regression analyses were carried out for SCPF. The independent variable selected for SCPF was monthly production (tons) of paper, the largest and main product (pulp is used to produce paper). The dependent variables were steam consumption, gas consumption, and electricity consumption (kWh). These analyses led to the development of factory energy performance model linear equations, of the form:

$$y = ax + b,$$

where y = dependent variable (energy consumption)
x = independent variable (production)
a = slope, "x coefficient" (variable energy per ton)
b = intercept, "constant"
(fixed energy consumption per day or month)

SLOKAS CELULOZES UN PAPIRA FABRIKA (Pulp & Paper)
MONTHLY PERFORMANCE DATA
JANUARY 1988 - NOVEMBER 1991

ENERGY CONSUMPTION REGRESSION ANALYSIS
EMPIRICAL PRODUCTION ENERGY MODEL EQUATIONS

1. RELATIONSHIP BETWEEN ELECTRICITY CONSUMPTION[4] AND TOTAL PAPER PRODUCTION

Average energy consumption = 10,818,213 kWh/month
Fixed energy consumption = 4,409,931 kWh/month
(Fixed consumption represents 40.8% of total)
Variable energy consumption = 951.27 kWh/ton
(in addition to fixed consumption)

Other details of Regression Output:
R Squared 0.882
(very good prediction)
t test 18.31
(strong correlation between energy and production)

2. RELATIONSHIP BETWEEN NATURAL GAS CONSUMPTION AND TOTAL PAPER PRODUCTION

Average energy consumption = 6,376,404 m^3/month
Fixed energy consumption = 2,482,600 m^3/month
(Fixed consumption represents 38.9% of total)
Variable energy consumption = 578 m^3/ton
(in addition to fixed consumption)

Other details of Regression Output:
R Squared 0.636
(fair prediction, RCG/Hagler, Bailly expects that prediction could be improved by adding a second independent variable, ambient temperature)
t test 8.87
(good correlation between energy and production)

[4] Includes both purchases from Latvenergo and self-generation.

SLOKAS CELULOZES UN PAPIRA FABRIKA (Pulp & Paper)
MONTHLY PERFORMANCE DATA
JANUARY 1988 - NOVEMBER 1991

ENERGY CONSUMPTION REGRESSION ANALYSIS
EMPIRICAL PRODUCTION ENERGY MODEL EQUATIONS

3. RELATIONSHIP BETWEEN STEAM CONSUMPTION AND TOTAL PAPER PRODUCTION

Average energy consumption = 68,767 ton/month
Fixed energy consumption = 22,795 ton/month
(Fixed consumption represents 33.1% of total)
Variable energy consumption = 6.82 TS/TP
(TS/TP = ton steam per ton paper, in addition to fixed consumption)

Other details of Regression Output:
R Squared 0.686
(fair prediction, RCG/Hagler, Bailly expects that prediction could be improved by adding a second independent variable, ambient temperature))
t test 9.91
(good correlation between energy and production)

4. RELATIONSHIP BETWEEN GAS CONSUMPTION AND STEAM GENERATION

Average energy consumption = 6,376,404 m^3/month
Fixed energy consumption = 557,597 m^3/month
(Fixed consumption represents 8.7% of total)
Variable energy consumption = 84.62 m^3/ton steam
(in addition to fixed consumption)

Other details of Regression Output:
R Squared 0.926
(very good prediction)
t test 23.71
(strong correlation between gas and steam production)

Daily energy/production relationships were also analyzed for November 1991. Using daily data, the correlation between energy and production gives a more accurate estimate of the control of production and energy relationship. For a typical Western pulp and paper plant, r squared of regression on daily should be 0.7 or greater, to indicate that energy consumption is controlled, and depends on production. For the November 1991 SCPF data, however, there does not appear to be any dependence of energy upon production, in other words energy (on a daily basis) appears to be a fixed cost, for the following relationships:

Independent variable	Dependent variable
Total paper production	Total electricity consumption
Total paper production	Total gas consumption
Shop 1 paper production	Shop 1 steam consumption
Shop 2 paper production	Shop 2 steam consumption
Cellulose production	Cellulose steam consumption
Lignosulfate production	Lignosulfate steam consumption

Daily natural gas consumption should be well correlated with steam production, with an expected r^2 regression of 0.9 or greater for a boiler system. However, r^2 of regression for SCPF is only 0.46 for November. This could indicate metering problems, incorrect understanding of the data, or the use of gas in other applications.

Production at the cellulose plant does not seem to be accurately measured, since it occurs in the daily data in only three discrete values.

IV. ENERGY PROCUREMENT AND COST ANALYSIS

SCPF purchases gas from Latvias Gas and electricity from Latvenergo, and pays in Rubles. SCPF has subscription contracts with each supplier that limit the quantity of power (in MW) or energy (in Gcal/day) that can be used. Further, each supplier has rationing or allocation systems in effect which further limit the availability of energy to SCPF. These situations were very acute during the time of the audit, because of severe energy supply shortages in Latvia, and uncertainty in its chief energy supplier, Russia.

For example, SCPF is limited in the quantity of gas it may use. Furthermore, this limit is subject to regular review. Thus when SCPF experiences a production problem, the supplier regards the reduction in gas usage as lasting energy conservation, and reduces the allocation to SCPF. This reduces the ability of SCPF to produce paper.

Similarly, in the case of electricity, SCPF is allocated a peak power demand according to various regimes of supply. Depending on peak load and available supply, Latvenergo informs large users of the regime, by making an announcement during radio programs. SCPF obtains a different allocation, according to which regime is in place. A telex connects SCPF to Latvenergo, so that there is direct monitoring of the load at SCPF on a near-continuous basis.
The cost of energy at SCPF, in Rubles, is still very low, compared to European prices. However, the penalty for exceeding the allocation, especially in the case of electricity, is very high, approximately 10 times the base tariff.

Energy prices applicable at SCPF

During the time of the audit, the Ruble suffered a severe and rapid devaluation. Energy prices, in Rubles, also increased rapidly during the period. Prices in Rubles as of November 1991, and a rate of exchange of 100 Rubles = US$1.00, are used below.

1. Financial energy prices are Latvian energy prices, as paid by SCPF. As of November 1991, these were as follows:

	Rubles	US$ equivalent
Gas, per Gcal	7.5	$0.075
Electricity, per kWh[5]	0.074	$0.00074

2. Economic energy prices are European market energy prices, not including local taxes. These market prices represent the equivalent cost to the economy of Latvia in the near future. As Latvia integrates with the rest of Europe, there will be a trend to increase prices until they reach these levels. As of November 1991, European market prices averaged:

	US$ equivalent
Gas, per Gcal	$12.00
Electricity, per kWh	$ 0.05
Peak demand, per kW per month	$ 5.00

As indicated above, 1991 financial prices in Latvia are only a small fraction of economic prices. In the case of gas, the economic value of the gas in the European market is more than 160 times the price paid by SCPF. For electricity, the economic value is about 67 times the financial price.

Expected 1992 energy costs at SCPF

1. Financial energy costs

Given the uncertainty in the energy sector in Latvia and Russia, it is impossible to predict the trend or average 1992 Latvian energy prices. For convenience, RCG/Hagler, Bailly estimates that the average 1992 prices in Latvia might be:

	Rubles
Gas, per Gcal	100
Electricity, per kWh	1.00

Based on these prices and 1992 planned consumption, financial energy costs are estimated as follows:

[5] Including base subscription demand charges.

	Purchases	Cost, Rubles
Gas, '000 cubic meter[6]	70,000[7]	60,000,000
Electricity, MWh	80,000	80,000,000
Total energy cost		140,000,000

2. Economic energy costs

Using European market prices, we can calculate the economic value of the energy consumption at SCPF as follows:

	Purchases	Value, US$
Gas, '000 cubic meter	70,000	7,000,000
Electricity, MWh	80,000	4,000,000
Peak demand, kW	19,000	1,000,000
Total energy value		12,000,000

Marginal 1992 energy costs at SCPF

The value of energy savings must be determined based on marginal costs. Marginal costs reflect mainly energy costs, and do not include the cost of labor or capital equipment, which are included in fixed costs. For the purposes of energy conservation projects at SCPF, the following represent marginal costs:

1. Marginal cost of steam

The marginal cost of steam depends on whether the heat value of returned condensate or the cost of water treatment is considered. For the repair of a steam leak, the savings should reflect the full kcal value of the steam and the fact that water treatment costs will be reduced.

[6] SCPF purchases gas in standard cubic meters. The calorific value of one cubic meter of gas varies with the composition of the gas. For the purposes of this calculation, we assume an average value of 8.5 Gcal per thousand cubic meters.

[7] About 600 Tcal

We have not estimated water treatment costs in this report. For other projects, appropriate assumptions should be made regarding the heat of condensate returned.

Based on a fuel-to-steam efficiency of about 85%, the marginal cost of steam is estimated as follows:

For steam leaks (or other cases where condensate is not returned):

	Economic	Financial
High pressure, 40 bar 440°C	$10.95/ton	92 Rubles/ton
Medium pressure, 10 bar	$ 9.19/ton	77 Rubles/ton
Low pressure	$ 9.09/ton	76 Rubles/ton

For other cases where condensate is returned:

	Economic	Financial
High pressure, 40 bar 440°C	$ 9.54/ton	80 Rubles/ton
Medium pressure, 10 bar	$ 7.78/ton	65 Rubles/ton
Low pressure	$ 7.68/ton	64 Rubles/ton

2. Marginal cost of electricity

Electricity energy savings projects should reduce consumption of purchased electricity. Self-generation of electricity should be maximized. Thus the marginal cost of electricity for SCPF is the base tariff (per kWh) of Latvenergo.

	Economic	Financial
Electric energy	$0.05/kWh	1.00 Ruble/kWh
Peak demand	$5.00/kW/month	

V. RECOMMENDATIONS FOR ENERGY EFFICIENCY IMPROVEMENT

RCG/Hagler, Bailly's recommendations for energy management and efficiency improvement have been grouped in three categories:

A. General and Energy Management - These projects are opportunities which are recommended for immediate action, and require little or no expenditure. These projects affect management systems and techniques, rather than process equipment. These projects are the primary focus of the USAID Emergency Energy Program for Latvia.

B. Low-cost, Short-term Improvements - These projects are low-cost improvements to process plant and equipment which are recommended for implementation in the short-term (in 1992). Because of the low cost and quick payback (less than one year), these projects could be implemented from the company's annual maintenance budget. Some of these projects may be of interest to the USAID Emergency Energy Program for Latvia.

C. Capital Improvements - These projects are longer term projects, requiring investment of more than $100,000. Such projects would require careful study, beyond the scope of this preliminary energy audit. These projects are also beyond the scope of funding under the USAID Emergency Energy Program for Latvia.

A. GENERAL AND ENERGY MANAGEMENT

PRODUCTION MANAGEMENT
SCPF Action A.1 -
Increase production at SCPF.

Existing conditions:

SCPF is unable to obtain sufficient pulp wood, energy and other raw materials because of market conditions. This turndown of the plant has severely increased specific energy consumption. As described above, about 30-40% of energy consumption is a fixed cost at SCPF.

Raw pulp wood is exported from Latvia at about $160 per cubic meter. Paper could be exported for about $1,200 per ton. Five cubic meters of pulp wood yield one ton of paper.

Recommended action:

RCG/Hagler, Bailly recommends that production at SCPF be increased in order to obtain the maximum economic benefit from the large capital investment in place at SCPF. Latvia should develop a free market for pulp wood and allow SCPF to compete in the market. SCPF is attempting to increase the development of export-oriented products, such as its new wallpaper line. Value-added to the economy of Latvia would be increased by exporting paper instead of pulp wood.

Expected results:

Based on the results of 1988-90, RCG/Hagler, Bailly estimates that an increase of production of at least 20% can be achieved in the short term.

The environmental impact of increased production should be considered, but such considerations are beyond the scope of this energy audit. Impacts are expected to be only marginal, since SCPF has already invested in modern water and air pollution control systems.

Economic analysis:

Using economic costs (European market prices for paper, pulp wood, and energy) and the factory energy performance model developed by RCG/Hagler, Bailly, we can estimate the annual net benefits of the project as follows:

Increased production value:
20% x 60,000 tons/yr = 12,000 tons/yr
12,000 tons/yr x $1,200/ton = $14.4 million/yr

Increased raw material value:
12,000 tons/yr paper x 5 m^3/ton = 60,000 m^3/yr
60,000 m^3/yr x $160/$m^3$ = $9.6 million/yr

Increased natural gas consumption:
12,000 tons/yr paper x 578 m^3/ton = 7,000,000 m^3/yr
7,000,000 m^3/yr x 8.5 Mcal/m^3 = 60,000 Gcal/yr
60,000 Gcal/yr x $12/Gcal = $720,000/yr

Increased electricity consumption:
12,000 tons/yr paper x 951 kWh/ton = 11,400,000 kWh/yr
11,400,000 kWh/yr x $0.05/kWh = $570,000/yr

Increased peak electrical demand = 0 (no impact, production will be scheduled over additional hours)

Net annual benefits:

Paper		$14,400,000
Less:		
	Raw materials	9,600,000
	Natural gas	720,000
	Electricity	570,000
Net benefits		$3,510,000

This action would benefit the economy of Latvia by $3.5 million per year.

A. GENERAL AND ENERGY MANAGEMENT

MANAGEMENT
SCPF Action A.2 -
Introduce a market-based energy management information and control system

Existing conditions

The system of management information and control in place at SCPF is typical of most factories in Latvia. Production is based on plans, and management exercises control over the process to see that the plan is carried out. These plans set performance targets, which are based on input and output quantities.

SCPF currently monitors most of the important energy consumption and conversion parameters vital to the efficient operation of the plant. Gas consumption, steam generation, electrical energy generation, electricity purchase, and the consumption of electrical energy and steam by various sub-areas of the plant are currently recorded on a daily basis. The data is collated every week or ten days and sent to a central accounting agency in Ventspils, more than 100 km away. This agency processes the data to produce a monthly report. Likewise, production figures for various portions of the plant, and in some cases for individual machines are currently collected and reported on a monthly basis.
Energy management at SCPF is the responsibility of the Energy Department. However, primary responsibility for energy consumption lies in the Production Departments, which have the major energy-using equipment. This system limits the ability of the Energy Department to improve energy efficiency in the plant. There is no "market" for energy in the plant, such as a transfer pricing system for steam or electricity.

Findings

RCG/Hagler, Bailly observes, and SCPF management agrees, that the system in place is a centralized reporting system, and not a management control system. The time delay between the data and reporting is too long to permit any control actions to be taken.
RCG/Hagler, Bailly analyzed monthly data during a 47-month sample period (1988-1991). Compared to our experience in carrying out similar analyses in other plants in other countries, the indicator of correlation, r squared, is typical for monthly performance data, but poor for daily (control-level) performance. This analysis indicates that (1) energy consumption varies for a given level of production, (2) energy consumption at SCPF more closely approximates a fixed cost than a variable cost, (3) energy efficiency is deteriorating at SCPF, largely because of reduced production.

In the short-run, such as on a batch, shift, or daily basis, energy consumption in the plant could be reduced by analysis of performance ratios such as energy per unit of production. This would give a good picture of how well the process is performing, in terms of energy efficiency, on a daily basis, so management can exert short-run control actions which would improve efficiency.

In 1991, Sloka invested in several IBM PS-2 computers for improved management. These computers are for the Director, Chief Engineer, and Accounts. The computer in Accounts was beginning to be put into use for accounts payable and receivable. The computers for the Chief Engineer and Director were not yet in use, because of lack of software and training.

Recommendation

The RCG/Hagler, Bailly team recommends that:

1. A market-based pricing system be established for energy usage in SCPF.

2. An active management control system be established, based on the market system. Incentives should be used if necessary.

1. Establish a market-based pricing system for energy

Saving money is more interesting than saving energy. Employees realize that the future of their jobs is now directly linked to helping the factory reduce costs. If a market-based system is established in the plant, employees will learn the cost of certain actions and behavior, and can be motivated to improve behavior.

There are several steps required to establish a market for energy at SCPF. RCG/Hagler, Bailly suggests:

Step 1 - The Energy Department should be established as a separate profit center or service company. The Energy Department should calculate its cost of doing business, including fuel and electricity purchases from energy suppliers such as Latvenergo and Latvias Gas, plus the cost of service provided by the Energy Department, as measured by amortization of capital equipment, cost of labor, and cost of maintenance. A decision should be made on an appropriate level

of profit. Some plants may wish to treat their Energy Departments as a non-profit center.

Step 2 - Based on the cost of service and the profit decision, the price of key energy forms should be calculated on a weekly basis by the Energy Department. These forms include gas, steam at various pressures, hot water, and electricity. A weekly list of energy prices should be circulated at the beginning of the week to Directors, all production managers and posted for employees[8].

Step 3 - Energy (electricity, steam, and gas) should be sold to the various departments on the basis of these prices. Meters should be installed at the borders of the various Departments, and used to perform the transaction. Daily, or shift, reading of meters should be integrated into weekly figures, corresponding to the energy prices.

Step 4 - Energy "bills" should be calculated by the Energy Department each month, and submitted to the Economics Department. These energy costs will be used as part of the cost of production calculation.

2. Establish a management information and control system

Collection and analysis of energy consumption data should be done on a daily basis, or even better, on a shift by shift basis. Shift supervisors from each of the major energy producing and consuming areas of the plant should report specific energy consumption figures (i.e. tons of paper per ton of steam or Gcal of steam per Gcal of gas). These data should be compared as to day-to-day performance, and the results of operating or equipment changes should be documented and fed back to operating personnel.
Plant management needs to be able to obtain the information needed quickly enough to exercise the control required to improve efficiency in the use of energy and other valuable inputs. There are several steps required to achieve closed loop control for efficiency.

[8] RCG/Hagler, Bailly suggests that SCPF might wish to consider listing two prices in the report, financial costs paid by SCPF (as determined by the Ruble or new LAT prices prevailing during the week) and economic costs as would be paid by an equivalent factory in Europe (using the economic prices shown in this report).

Step 1 - The daily report should be modified to include energy consumption (steam, fuel and electric) and a calculation of the ratio of energy consumption to metric tons of production.

Step 2 - A management information and control system (M.I.C.S.) should be installed on a personal computer to provide the information necessary for energy management. This system must have software designed to calculate the necessary performance ratios and to present information to management in an easily-understandable form.

Step 3 - Management must use the information to make short-term management decisions which lead to control actions (changes) which affect plant operations. A plant-wide management control system should be developed on a daily basis.

Step 4 - Realistic energy management targets should be set, based on improvements in performance ratios. Specific projects, operational changes, and maintenance procedures should be carried out in order to achieve these targets and success of these actions should be measured and documented by the M.I.C.S.

Daily tracking of energy efficiency is a crucial step in establishing an effective energy management program. Without proper monitoring of consumption, it is impossible to prioritize potential energy conservation projects or to measure their effectiveness once they are implemented. Daily tracking provides immediate feedback for the evaluation of changes in operating practices or warning of equipment degradation or failure. Since the control of some of the major energy consuming equipment such as the boilers is done on a largely manual basis, it is important to provide timely feedback to operators as a means of helping them to control the equipment most efficiently. Boiler operating efficiency is not currently measured, so operators have no basis for improving their performance from an efficiency standpoint.

Secondly, a detailed monitoring program can provide warnings as to the degradation or failure of important equipment. For example, a sudden jump in the specific steam consumption for one of the paper machines might signal a failed steam trap. If the consumption data are averaged over an entire month, the failure would be more difficult to spot and a great deal of money could be wasted before corrective action was taken.

Finally, a thorough energy monitoring program will increase the awareness of both supervisory and operating personnel to the importance of energy conservation, resulting in cooperation and perhaps contribution of ideas to assist the program. Workers at all levels must be enlisted as partners for energy conservation programs to work effectively.

SCPF may wish to consider incentives, such as sharing part of the energy savings with employees. One way this is done in the US is a "Suggestion Box". Employees can put their ideas for energy saving projects in the Box, and if the idea is carried out, they can be awarded a cash prize, based on the net cost savings.

Expected results

The precise savings that can be achieved by establishing such a program are impossible to estimate accurately, but experience has shown that from 1-15% percent reduction of energy costs have been attributed by other plants to their market-based monitoring programs. This is based on experiences of similar companies in the U.S. and Europe before implementing such systems.

The investment required to implement the program is minimal. SCPF already has installed computers and sufficient instrumentation to begin. Over time, additional equipment could be purchased for submetering of steam and electricity consumption by various equipment, financed from the savings generated by conservation projects.

Based on the high fixed energy consumption at SCPF, and the observed variability in the regression analysis for SCPF, RCG/Hagler, Bailly estimates a potential savings of 2-5% for natural gas, steam and electricity in calculating the benefits of the system. The expected economic value of the energy savings is $224,000 per year:

Fuel and steam - market based management control

1992 natural gas consumption 70 million m^3 (600,000 Gcal), at an economic cost of $12/Gcal and financial cost of 100 Rbl/Gcal.

annual benefit estimate (2%) = 12,000 Gcal

$144,000 per year

1.2 million Rubles per year

Electric - market based management control

1992 electricity consumption 80,000 MWh, at an economic cost of $50/MWh and financial cost of 1,000 Rbl/kWh

annual benefit estimate (2%) = 1,600 MWh

$80,000 per year

1.6 million Rubles per year

Additional savings, such as reduced use of raw material and reduced generation of scrap are possible but are beyond the scope of this report and are therefore not estimated.

Equipment required:

Personal computer (IBM compatible) for energy department:

(1) 286, VGA, 2 MB RAM, 20 MB disk
(1) 24-pin dot matrix wide carriage printer
(1) spreadsheet software (Lotus 1-2-3)
total estimated cost $4,000

Spreadsheet software development:

local contract - $10,000

Staff training:

local contract - $10,000

Total development cost = $24,000

Annual incremental costs:

additional metering equipment and maintenance - $5,000

Financial analysis

The payback period for the project is less than four months:

Payback = capital cost/net annual cost savings

$24,000/($224,000 - $5,000) = 0.1 year

A. GENERAL AND ENERGY MANAGEMENT

ENERGY & UTILITIES
SCPF Action A.3 -
Put energy efficiency teams in action to reduce energy losses

Existing conditions:

Energy requirements at SCPF are growing year-by-year for a given level of production. This is indicative of a deteriorating situation which could benefit from increased maintenance.

During the audit, the RCG/Hagler, Bailly team observed steam leaks and compressed air leaks with substantial energy cost in the plant.

Recommended action:

RCG/Hagler, Bailly recommends that SCPF form "Energy Efficiency Teams" for steam, electric motors, and compressed air. Personnel for this team should be drawn from SCPF staff, and this exercise should become a continuous part of plant operations and maintenance.

The Steam Efficiency Team would be responsible for the identification and repair of leaks in steam systems, and to inspect and repair thermal insulation. The Electric Motor Efficiency Team would be responsible to survey electric motor load and efficiency, check and clean motors, replace underloaded motors, rewind or replace motors with excessive reactance, and develop a plan for introduction of high efficiency motors. The Compressed Air Efficiency Team would be responsible to evaluate efficiency of compressed air systems, and to seek out and repair leaks in compressed air lines.

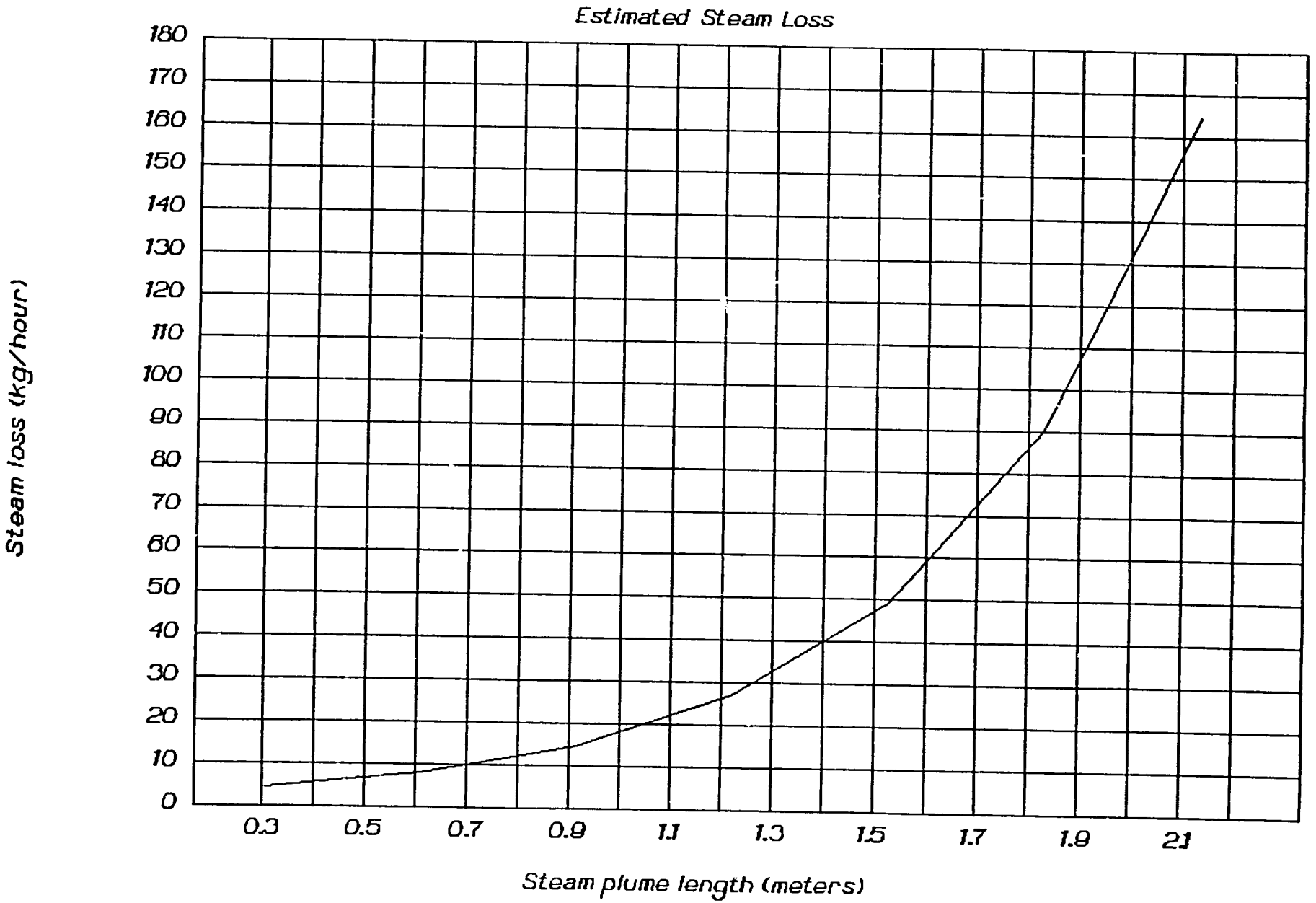
The Steam Efficiency Team should have the following tasks:

- Develop an inventory of the uses of steam in the plant.
- Carry out a survey of the condition of steam pipe insulation in the plant, using thermocouples and other temperature indicators.

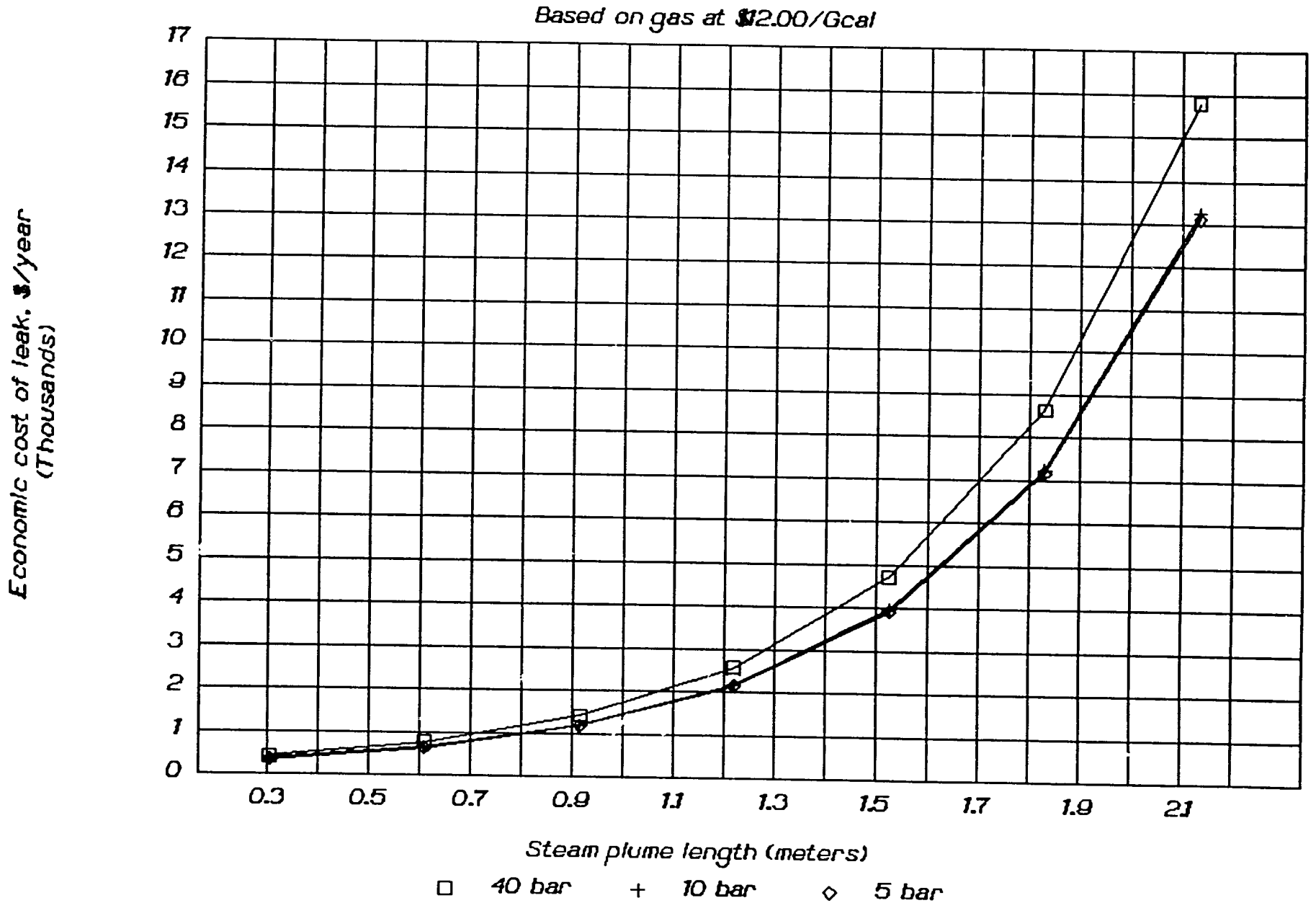
- Check the operation of all steam traps in the plant on a monthly basis, using the "glove test" or other simple methods. Repair or replace leaking traps as found.

- Carry out a survey of steam leaks on a monthly basis. For each leak found, make an estimate of the "plume length" (visible length of steam vapor). Use the steam leak charts on the following pages to estimate the quantity (kg/hour) of the leak and the annual economic cost of the leak (US dollars of fuel imported to Latvia, based on leak at 8,760 hours per year). Estimate the financial cost of the leak, based on the value of steam and estimate the cost to repair the leak. If the payback period is less than 1 year, recommend the repair of the leak. Develop a log to keep track of the growth of leaks from month-to-month. Develop a monthly plan for repairs.

STEAM LEAK


Estimated Steam Loss
Steam loss (kg/hour)
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
0.3
0.5
0.7
0.9
1.1
1.3
1.5
1.7
1.9
2.1
Steam plume length (meters)

SLOKA PULP & PAPER - STEAM LEAK COST



The Electric Motor Efficiency Team should have the following specific tasks:

- Based on nameplate and available meters, make a complete inventory of all motors over 10 kW, which identifies the motor number, rating (kW), location, age, voltage, rpm, running amperes, expected annual energy consumption, description of use.

- Obtain curves of efficiency vs. percentage load and power factor vs. percentage load from SCPF's major suppliers of motors families of motors now installed in the plant.

- Develop specifications for the procurement of new motors for the plant, for new applications. Obtain manufacturer's data on price, efficiency and power factor (cos phi) for alternative lines. In the U.S., manufacturers offer two types of electric motors - standard motors and high efficiency motors which reduce energy consumption by 3-10% for the same application. The increase in efficiency is greatest for smaller sizes (under 50 kW), since large motors are relatively efficient. The high efficiency motor costs about 50% more than the standard motor, but in applications with high duty factor (over 4,000 hours per year, like SCPF), this incremental cost can be recovered in one year or less. RCG/Hagler, Bailly expects that the results of this analysis will result in the development of a new specification, for high efficiency motors.

- After carrying out the analysis and developing the new high efficiency specification for new motors, consider the possible replacement of existing motors with high efficiency motors on a phased basis. One way to implement this policy would be to buy a quantity of high efficiency motors which would be used to replace burned-out motors, instead of rewinding them. Often, rewound motors have lower efficiency than new motors, as the magnets can suffer reduced flux if they are overheated in the process. Efficiency loss can also result because rewinding is usually done to lower quality standards than new manufacturing, so increased friction can result from slight misalignment. Finally, if wire of smaller diameter or higher resistivity is used in the rewind job, resistive losses will increase. It is the RCG/Hagler, Bailly team's experience that a rewound motor has an efficiency 1-5% less than a new motor, and rewinding costs 50% or more of the cost of a new motor.

- Using combination portable volt-ammeter & power factor meter, carry out an electric motor load survey. The load (kW, kVAR, cos phi), voltage on each

phase, and efficiency of all motors over about 10 kW should be checked using a systematic procedure.

- Using a strip-chart demand recorder, carry out power demand survey (kW, kVAR, metered demand kW, and kWh/shift) for load centers over 100 kW. Based on this data, develop a power demand balance for the plant, under various operating conditions.

- Based on the results of the power demand survey, work together with process personnel to investigate ways to reschedule operations to reduce peak demand and to shift consumption from peak to off-peak hours.

- If motors with excessive reactance are identified, they should be taken out of service for rewinding or replacement.

- Institute a monthly policy of motor maintenance. Check that bearings are getting proper lubrication. Electrical connections should be checked and tightened if necessary. The housing and ventilation air intake on all motors should be cleaned to improve cooling and efficiency. Compressed air should be used to blow out dust and dirt from internal parts of the motor (air should be dry and less than 4 bar pressure to avoid damaging insulation). The motor and its drive system drive should be checked for proper alignment, proper belt tension, and proper lubrication. Insulation should be tested with a megohmeter, and a log should be kept of these readings so that comparisons can be made from month-to-month. Check for excessive vibration.

- As underloaded motors are identified by the survey, they should be changed for motors appropriately sized for the job. The inventory (developed above) should serve as the basis for moving motors from one location to another within the plant to match sizes to loads. If properly sized motors are available from spares or stocks, replacements of a given kW rating should prioritized on the basis of the possible efficiency improvement (degree of underloading and operating hours per year).

- If phase-to-phase voltage imbalance is found (over 2%), then adjustments should be made to correct the problem. For every 2% variation in phase-to-phase voltage, a motor loses about 1% in efficiency. For the 0.4 kV system, the phase voltages should be equal within ± 5 volts, otherwise efficiency is reduced. Voltage imbalance can be caused by loose or corroded connections at bus bars, starter terminals, fuses, or the motor itself. If the problem is

caused by single-phase loads which are attached one of the phases, these loads should be more equally distributed among the phases, or else the transformer should be retapped.

- An inventory of on-peak (day) and off-peak (night) uses of electricity should be made. Based on this inventory, priorities should be established, and candidates should be identified for shifting non-critical activities from on-peak to off-peak. These shifts will achieve financial benefits, because the cost of electricity during off-peak hours is only one-half that during on-peak.

The Compressed Air Efficiency Team should have the following tasks:

- Based on design data, make an inventory of all uses of compressed air
- On a monthly basis, carry out an analysis of air compressor efficiency and record in logbook. If less than design, investigate the causes.
- Using ultrasonic detector, carry out a survey of the plant every month to identify compressed air leaks, and record them in a log book. Estimate the flow of leaks (or measure using a velometer) and prepare a report, with the monthly cost of each leak clearly indicated. Develop a plan for leak repair, based on priority.
- During plant shutdowns, record the duration of air compressor cycle times (period of time compressor is running). This shows the amount of energy required to serve the leaks (fixed energy consumption).

Expected results:

The precise savings that can be achieved by establishing such a program are impossible to estimate accurately, but experience has shown that from 1-20% percent reduction of energy costs have been attributed by other plants to their market-based monitoring programs. This is based on experiences of similar companies in the U.S. and Europe before implementing such systems.

Based on the high fixed energy consumption at SCPF, and the observed variability in the regression analysis for SCPF, RCG/Hagler, Bailly estimates a potential savings of 5-10% for natural gas, steam and purchased electricity consumption in calculating the benefits of the system. The economic and financial benefits of these savings are $617,000 per year, or & million Rubles per year, estimated as follows:

Electric power: 5% x 19 MW = 950 kW
Economic: 950 kW x $5/kW/mo x 12 mo/yr = $57,000/yr

Electric energy: 5% x 80,000 MWh/yr = 4,000 MWh/yr
Financial: 4,000,000 kWh/yr x 1 R/kWh = 4 million R/yr
Economic: 4,000,000 kWh/yr x $0.05/kWh = $200,000/yr

Thermal (natural gas for steam):
5% x 600,000 Gcal/yr = 30,000 Gcal/yr
Financial: 30,000 Gcal/yr x 100 R/Gcal = 3 million R/yr
Economic: 30,000 Gcal/yr x $12/Gcal = $360,000/yr

The maintenance program will increase motor life, thereby reducing replacement and rewinding costs over the long run. The maintenance and monitoring program will also reduce the frequency of shutdowns in production operations because of motor failures, thereby having a productivity benefit. These benefits are not estimated in this report.

Equipment required:

(1) Digital strobe tachometer
(1) Digital multimeter/megohmeter with current clamp and Power factor meter
(1) Ultrasonic flow detector
(1) Digital thermocouple indicator and probes
(1) Infrared thermometer
total estimated cost $15,000

RCG/Hagler, Bailly estimates that SCPF should budget $50,000 per year for additional incidental equipment and repairs (additional maintenance), such as steam traps, insulation, motors, and the like.

Financial/economic analysis:

Based on a cost of $15,000 and a net savings of $567,000 per year, the project payback period is about one week.

A. GENERAL AND ENERGY MANAGEMENT

ENERGY & UTILITIES
SCPF Action A.4 -

Improve combustion control in boilers, repair leaking furnace or air preheater if necessary.

Existing conditions:

The steam boilers consume large quantities of gas; their efficiency should be maintained to within a fraction of a percent. Flue gas measurements performed on two of the high pressure boilers during the audit showed significant quantities of O_2 in the exhaust, with no appearance of carbon monoxide, due to operation at high excess air. A summary of the average measurements made, along with expected corrected conditions is presented in the following table.

Boiler:	#6	#7	corrected
Date of measurement:	10 Dec	11 Dec	
Load:	80%	80%	80%
Fuel:	gas	gas	gas
Inlet air temp.	40 C	40 C	40 C
O_2:	9.0%	12.5%	3.0
CO:	0 ppm	0 ppm	0 ppm
combustibles:	0.0%	0.0%	0.0%
Stack temperature:	180 C	184 C	180 C
CO_2 (calculated):	7.0%	5.3%	11%
Excess air:	68%	120%	15%
Comb. efficiency:	90.1%	88.0%	93.6
Radiation losses (est.)	1.5%	1.5%	1.5%
Blowdown losses	1.5%	1.5%	1.5%
Overall efficiency:	87.1%	85.0%	90.6%

Recommended action:

Purchase a portable electronic gas analyzer (consisting of electronic oxygen sensor, electronic carbon monoxide sensor, and thermocouple probe, with wet chemical kit as back-up) to measure stack gases and calculate boiler efficiency. Use this system on each boiler twice a week if loads are constant, and daily if loads are varying significantly. Also use this system to confirm the nomograph for air pressure relative to fuel pressure. Based on the readings of

the analyzer, adjust the air damper to provide the optimum fuel-air ratio (maximum CO_2 with minimum CO).

The high excess air readings could result from infiltration of air from leaks in the furnace, in the air preheater, or through the ductwork. Either way, this represents a waste of energy since too much air is being heated instead of making this heat available for transfer to the steam.

Expected results:

According to the measurements described above, Sloka boilers are operating 4 to 5% below their optimal (design) efficiency. Without necessity of investment in new burners or control systems, it is estimated that a minimum of 1% efficiency improvement can be made with a closer monitoring and adjustment of fuel/air conditions, or by repairing air leaks. The energy savings is estimated at 3% of the annual gas consumption.

Thermal (natural gas for steam):

3% x 600,000 Gcal/yr = 18,000 Gcal/yr
Financial: 18,000 Gcal/yr x 100 R/Gcal = 1.8 million R/yr
Economic: 18,000 Gcal/yr x $12/Gcal = $216,000/yr

Financial/economic analysis:

The cost of a portable combustion analyzer is estimated at $5,000. The cost of repairing air leaks was not estimated as part of the audit. A budget of 1 million Rubles for the repair project would give a financial payback of about six months. The economic payback would be less than one month.

A. GENERAL AND ENERGY MANAGEMENT

ENERGY & UTILITIES
SCPF Action A.5 -
Maximize electricity generation

Existing conditions:

Electric energy generation at SCPF has declined significantly in recent years.

As described above, Sloka has two steam turbine generators. Under existing operations, as observed during the audit, only Turbine #2 is operating, and as much as 25 t/h steam are being throttled across a pressure reduction station.

If Sloka can operate their Turbine #1, with extraction of 5 bar steam and a minimum condensing load, they are able to generate electricity at an efficiency close to that of Latvenergo, since all the 5 bar steam can be used in the process. Our calculations show that if the gas allocation to Sloka can be increased by approximately 10% (1200 Nm3/h), Sloka will be able to generate between 3.5 and 3.8 MW of electricity, resulting in the following advantages:

- an increase of electricity production at high thermal efficiency in Latvia, where more than half of all electricity is imported and electric energy is sorely needed
- important cost savings to Sloka, allowing them to improve their overall competitiveness in paper production
- improvement of overall thermal efficiency at Sloka, since the warmed condenser cooling water can be used in the process, thereby recovering some of the heat lost in the condensation process.

Because of the minimum condensing flow requirement on Turbine #1, and because all existing steam is needed in the production process (including some district heating) this recommendation cannot be implemented without the increase in fuel supply. SCPF does have the ability to burn fuel oil.

Recommended action:

Operate both steam turbine generators whenever allowed by both the process steam load and the natural gas consumption limits. Pursue the use of fuel oil, either mazout or light oil, to augment fuel supplies.

Expected results:

The calculation of savings is based on the difference in the cost of electricity generated and the cost of additional gas consumption in the boilers. It is assumed that Sloka could operate in this mode for at least 6,000 hours per year. Additional operating costs, including condenser cooling water pumping are estimated to be a few percent of the electricity generated, and are considered included in the conservative number of 3.5 MW average generation.

Benefits:

Electric power: 3.5 MW
Economic: 3,500 kW x $5/kW/mo x 12 mo/yr = $210,000/yr

Electric energy: 3.5 MW x 6,000 h/yr = 21,000 MWh/yr
Financial: 21,000,000 kWh/yr x 1 R/kWh = 21 million R/yr
Economic: 21,000,000 kWh/yr x $0.05/kWh = $1,050,000/yr

Costs:

Thermal (increased natural gas for steam):
1,200 nm^3/hr x 6,000 hr/yr x 8.5 Mcal/nm^3 = 61,000 Gcal/yr
Financial: 61,000 Gcal/yr x 100 R/Gcal = 6.1 million R/yr
Economic: 61,000 Gcal/yr x $12/Gcal = $730,000/yr

Additional maintenance costs for the turbines are estimated as $20,000 per year, or less.

Economic/financial analysis:

Net benefits:

Financial: 14 million R/yr
Economic: $530,000/yr

The payback is immediate. The cost of implementation of this project is negligible. Turbine 1 is available to go on line at any time; no additional operating staff are necessary.

Schedule:

The implementation of this project depends on the availability of gas in Latvia. At an initial meeting among representatives of RCG/Hagler, Bailly, SCPF, Ekodoma, Latvenergo, and Latvias Gas held in January 1992, it was made clear that no increase in the allotted gas amount was possible in the foreseeable future, due to the extreme fuel crisis in Latvia. However, SCPF should continue to communicate with Latvias Gas to determine the earliest point at which the small increase in gas supply would be allowed, and should consider light oils if available.

A. GENERAL AND ENERGY MANAGEMENT

ENERGY & UTILITIES
SCPF Action A.6 -
Improve boiler water treatment efficiency

Existing conditions:

Total dissolved solids (TDS) concentration in the boiler was measured during the audit. For boilers at 40 bar operating pressure, the American Boiler Manufacturers Association recommends a limit of 2,500 ppm. Reducing TDS below this limit requires additional blowdown, with resultant heat loss.

Recommended action:

Acquire a TDS monitor and use it in the laboratory for boiler water testing every 2-4 hours. Reduce blowdown to achieve TDS of 2,000-2,500 ppm. The estimated cost of equipment is $500.

Expected results:

Improved boiler water treatment will either enable reduced blowdown (reducing heat losses) or will increase blowdown (thereby reducing the buildup of scale on the boiler heat transfer surfaces, improving heat transfer effectiveness). Either result will reduce natural gas consumption slightly, less than 1%.

Thermal (reduced natural gas for steam):
0.2% x 600,000 Gcal/yr = 1,000 Gcal/yr
Financial: 1,000 Gcal/yr x 100 R/Gcal = 100,000 R/yr
Economic: 1,000 Gcal/yr x $12/Gcal = $12,000/yr

Economic/financial analysis:

The estimated payback period is less than 0.1 year.

B. LOW-COST, SHORT-TERM IMPROVEMENTS

PAPER PRODUCTION

SCPF Action B.1 -

Improve drying efficiency - install fixed humidity sensors for paper drying machines

Existing conditions:

Moisture content of paper is not being measured on production lines, resulting in overdrying (waste of energy, increased cost of production) or underdrying (reduced quality of product). Scanners are in place, and equipment was originally installed, but has been inoperable since 1974, for lack of hard currency. Typical conditions of SCPF paper as measured by the SCPF laboratory are 5% moisture content, against a specification of 8%, indicating overdrying. For an initial moisture content of 36-40% before the dryer, this overdrying represents additional energy consumption of about 10%.

Recommended action:

Install fixed instruments to make continuous measurements of paper humidity on paper drying production lines for machines #7 and #8. Locate sensors at two locations, at output and intermediate point. Adjust production conditions, particularly steam flow to the dryers, in response to the readings shown by these instruments.

Expected results:

Steam savings of at least 5% are estimated for each paper machine. This represents approximately 2% of annual gas consumption at SCPF.

Thermal savings (natural gas for steam):

2% x 600,000 Gcal/yr = 12,000 Gcal/yr
Financial: 12,000 Gcal/yr x 100 R/Gcal = 1.2 million R/yr
Economic: 12,000 Gcal/yr x $12/Gcal = $144,000/yr

The estimated cost of retrofitting the existing scanner installations is $15,000. If complete new scanner systems are required, the cost could be $100,000 or more.

Other benefits include the value of quality improvements and possible reduction in scrap. The value of these benefits is substantial, but is not estimated in this report.

Economic/financial analysis:

The payback period is less than one year.

B. LOW-COST, SHORT-TERM IMPROVEMENTS

PAPER PRODUCTION
SCPF Action B.2 -
Improve steam system efficiency - install steam traps on paper drying machines

Existing conditions:

Steam traps for paper machine number 5 are old and leaking live steam to the condensate lines. These traps should be replaced.

Recommended action:

Procure and install 30 modern inverted-bucket type steam traps.

Expected results:

The cost of the equipment is estimated as $6,000, with installation costing $1,000 more. The estimated benefits, in the form of energy savings, are 5% of steam consumption on machine #5, or about 0.5% of total gas consumption.

Thermal savings (natural gas for steam):
0.5% x 600,000 Gcal/yr = 3,000 Gcal/yr
Financial: 3,000 Gcal/yr x 100 R/Gcal = 300,000 R/yr
Economic: 3,000 Gcal/yr x $12/Gcal = $36,000/yr

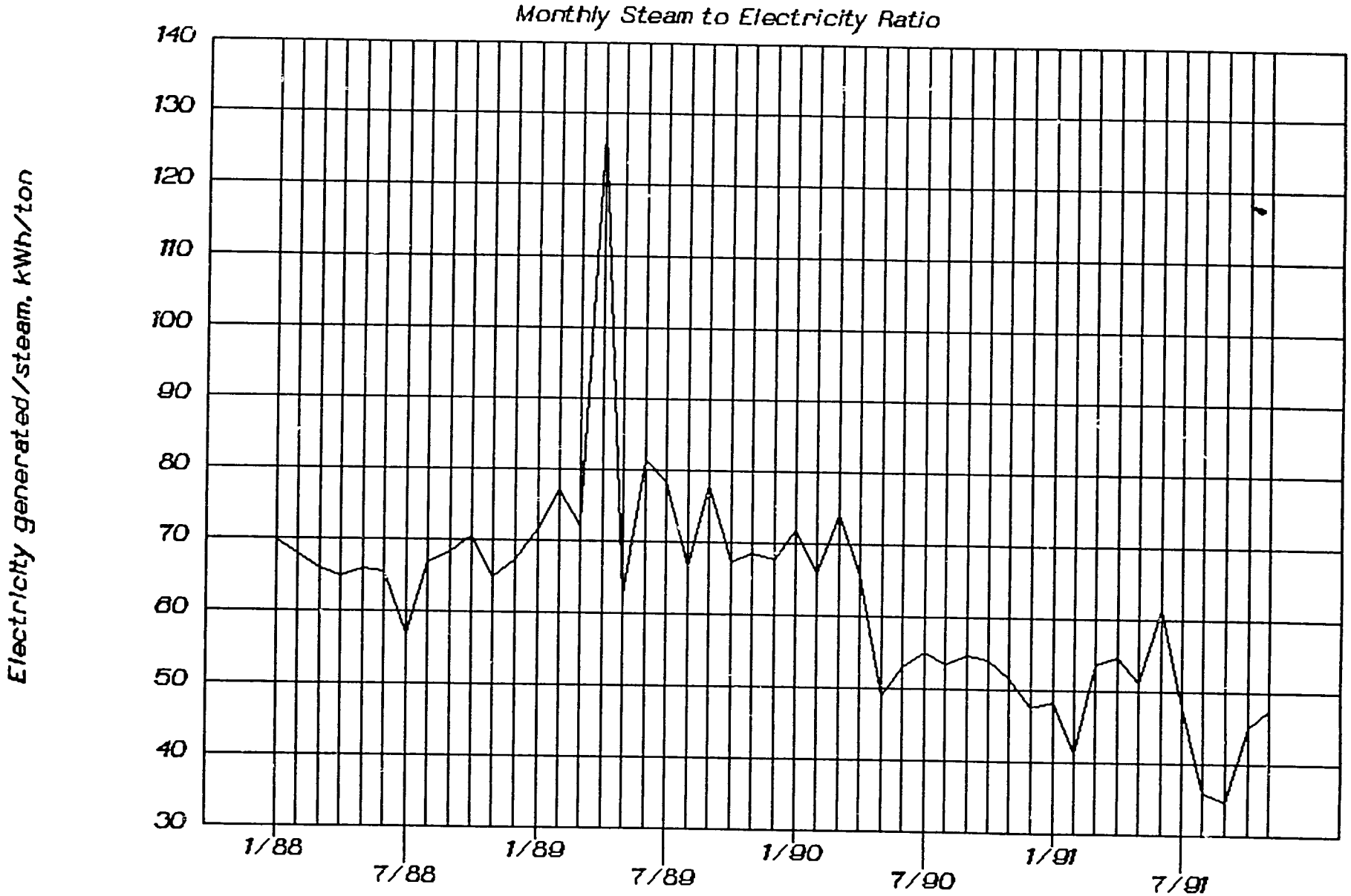
Economic/financial analysis:

The estimated payback period is 0.2 year.

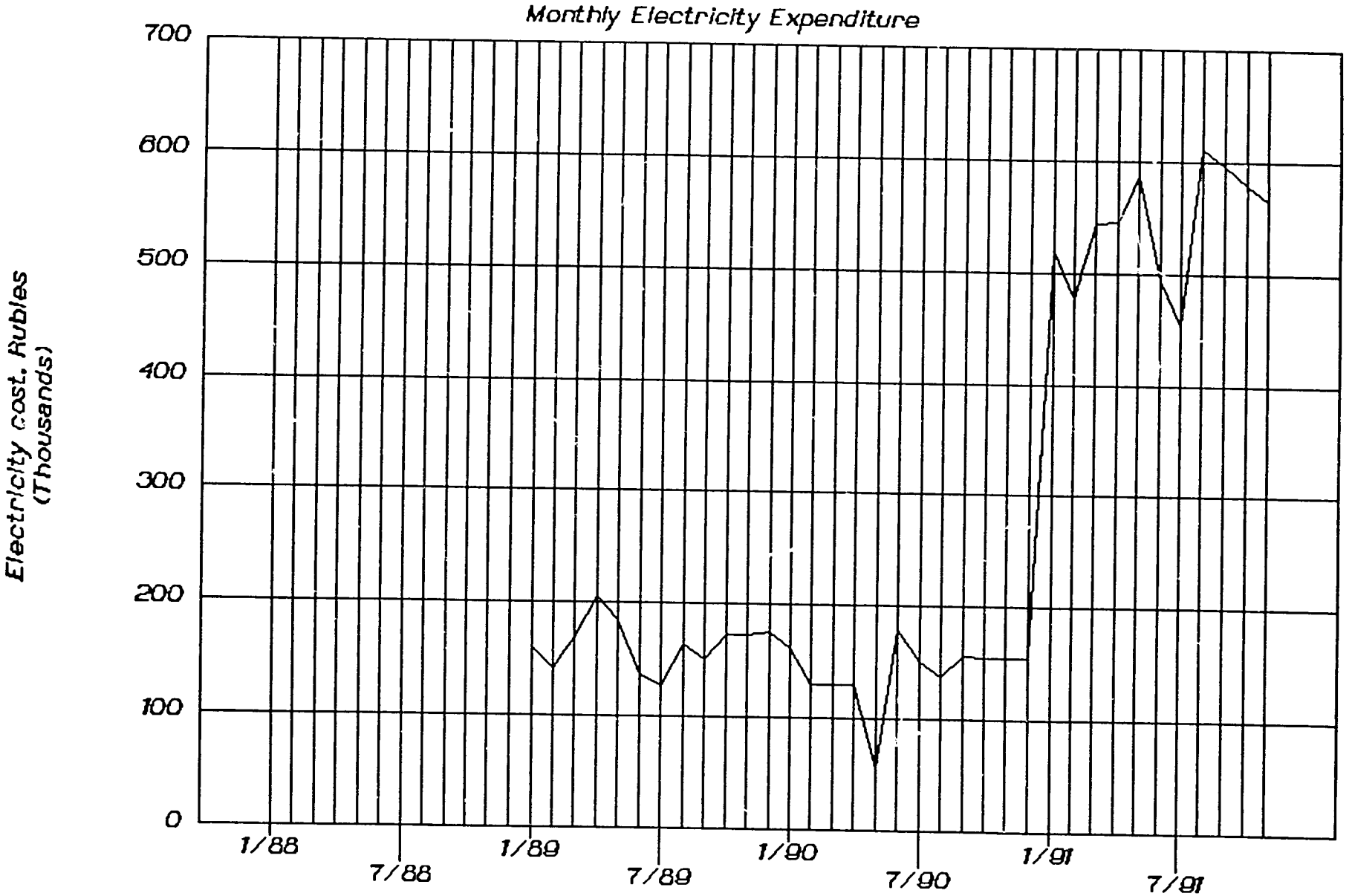
APPENDICES

SPREADSHEET AND GRAPHICAL PRESENTATION OF ENERGY DATA
SLOKAS CELULOZES UN PAPIRA FABRIKA (PULP & PAPER)

SLOKA PULP & PAPER - ENERGY EFFICIENCY



SLOKA PULP & PAPER - ENERGY COST



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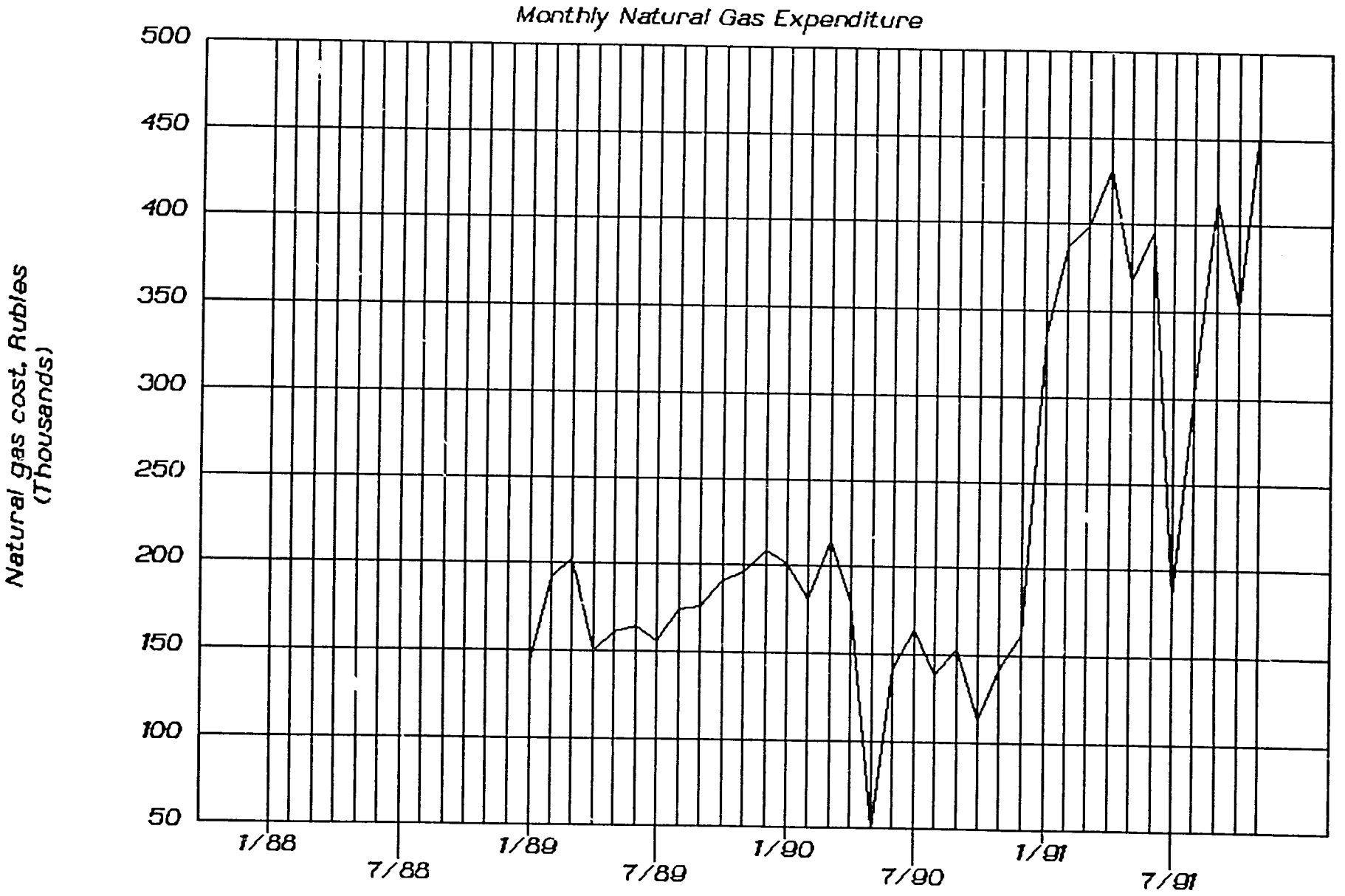

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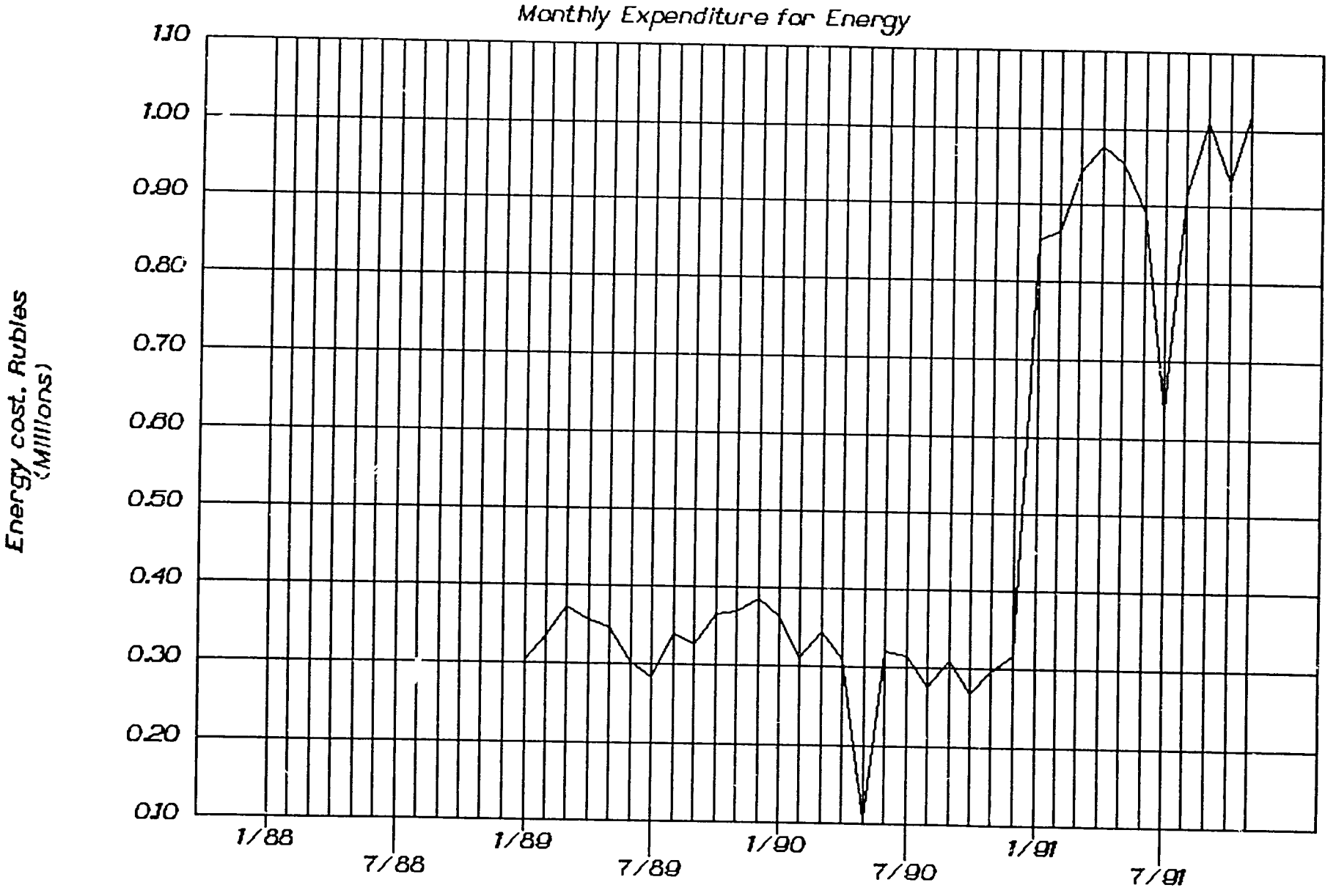

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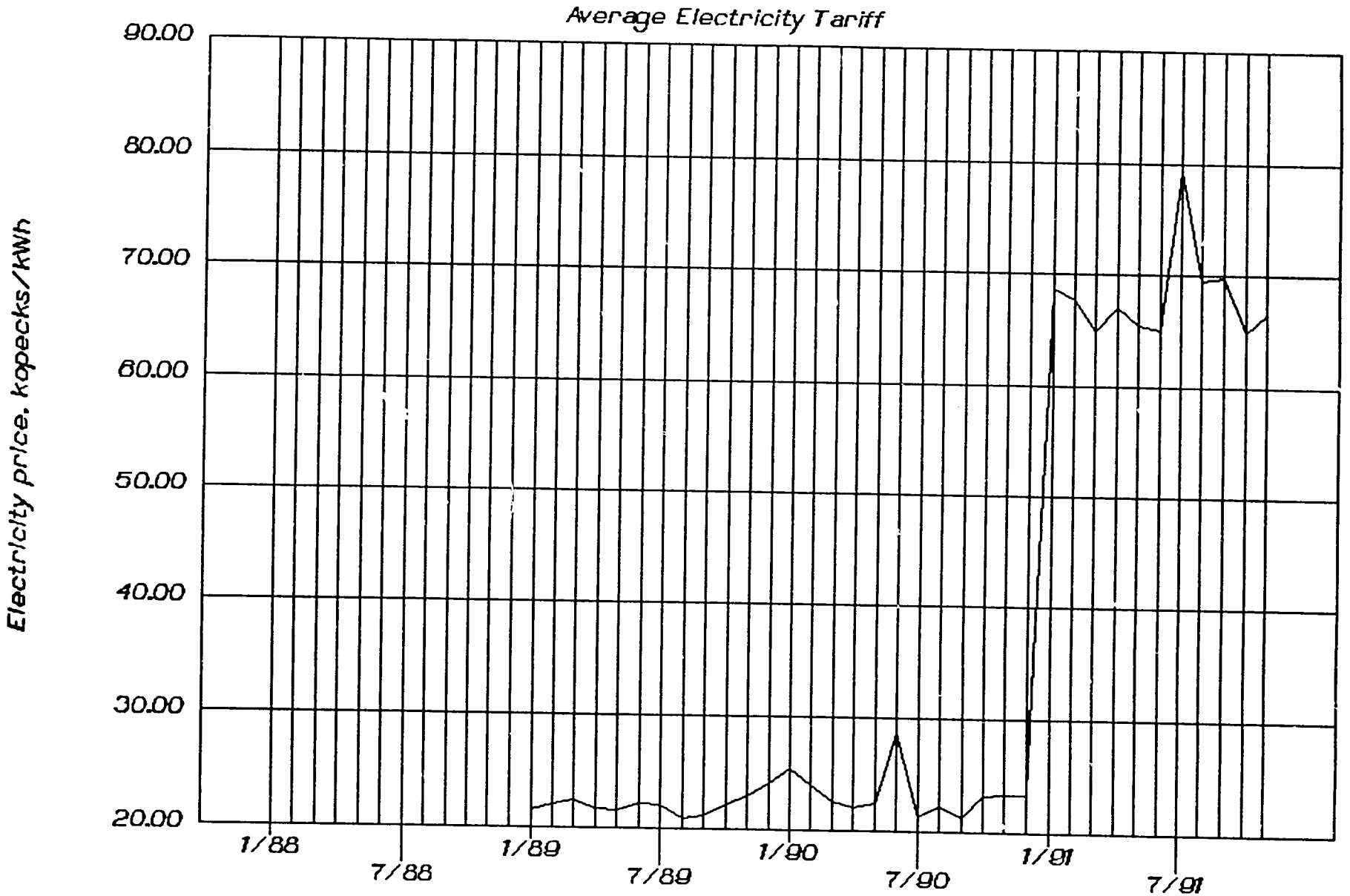

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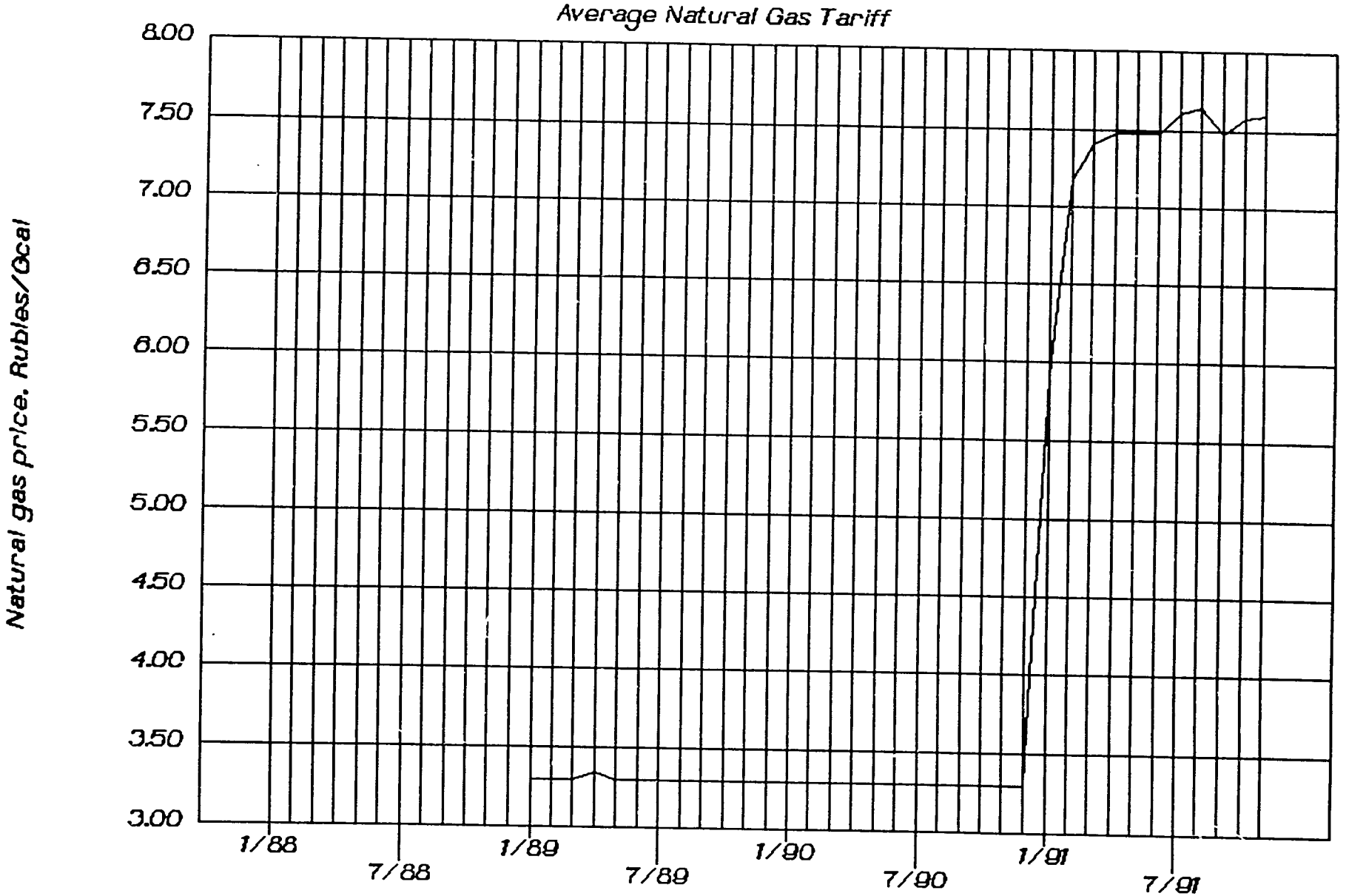
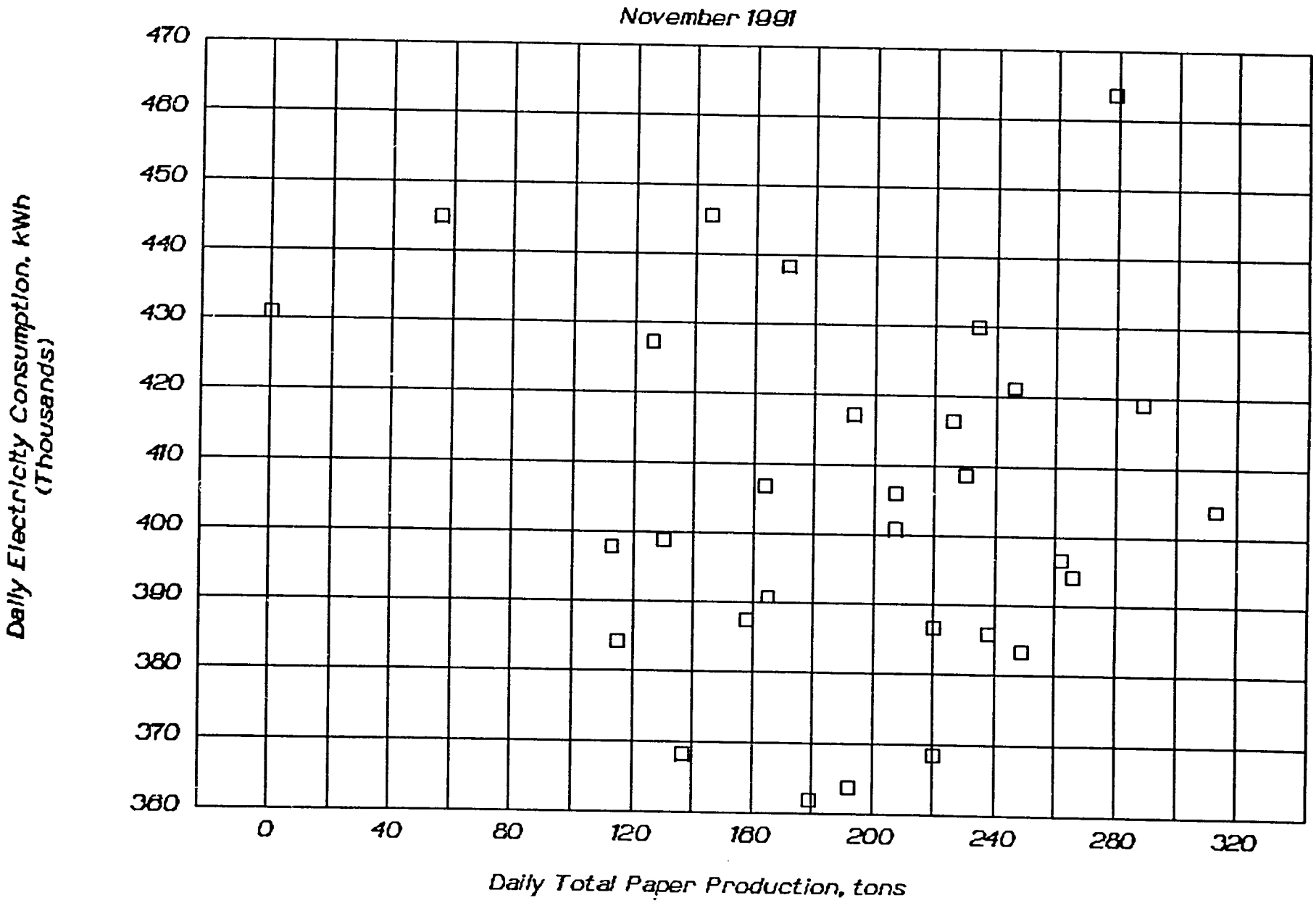
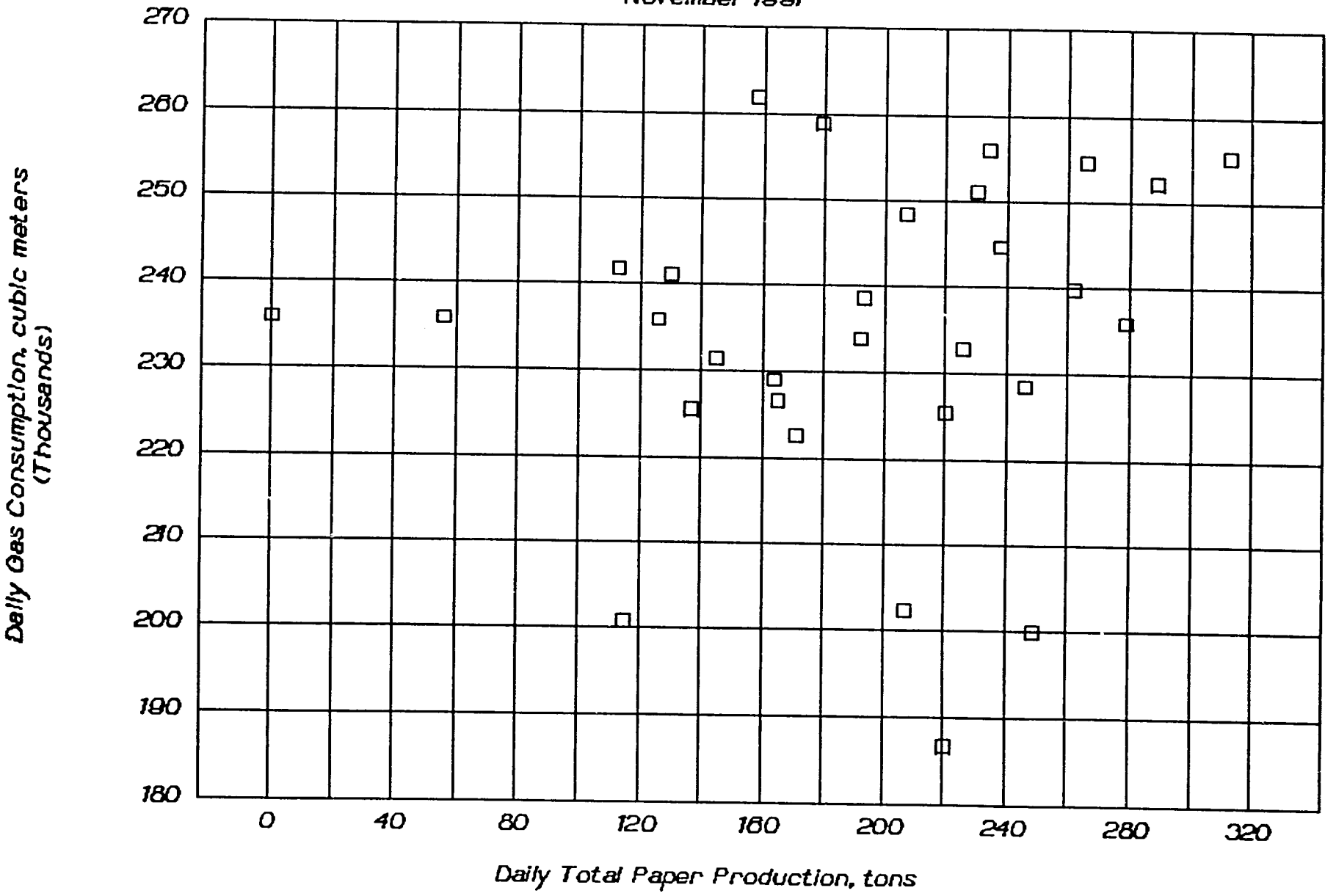


SLOKA PULP & PAPER - ENERGY/PRODUCTION



SLOKA PULP & PAPER - ENERGY/PRODUCTION

November 1991



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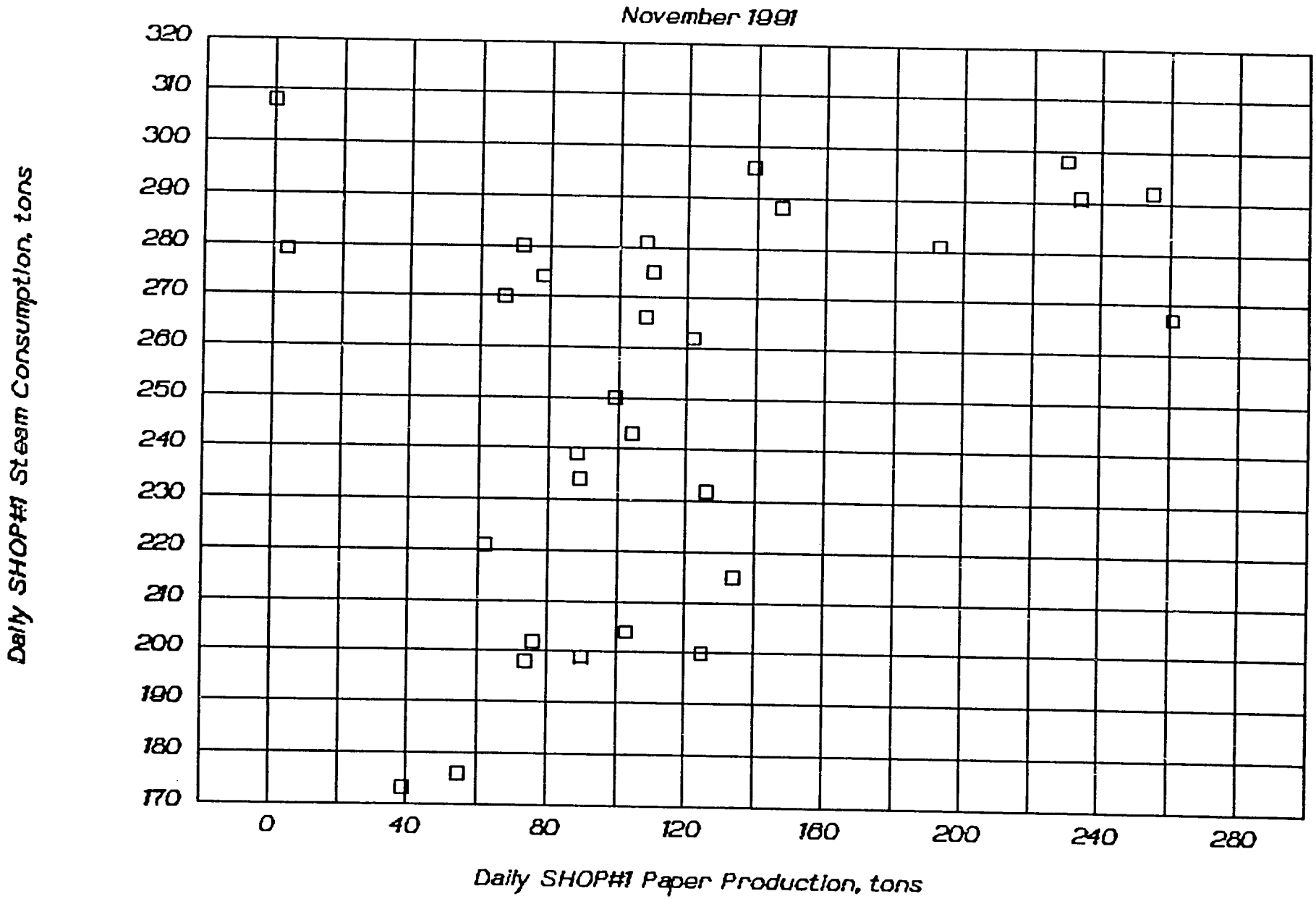

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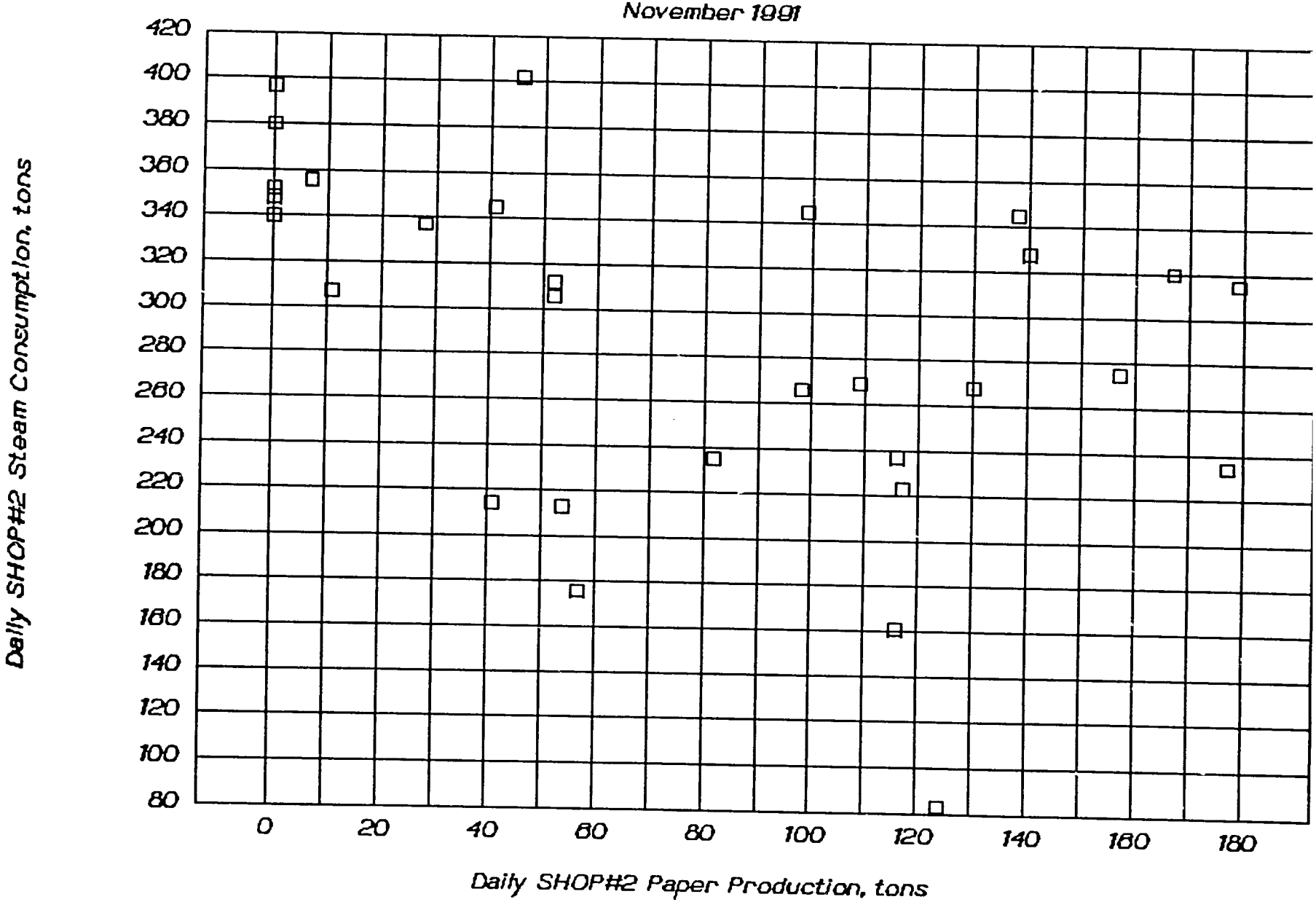

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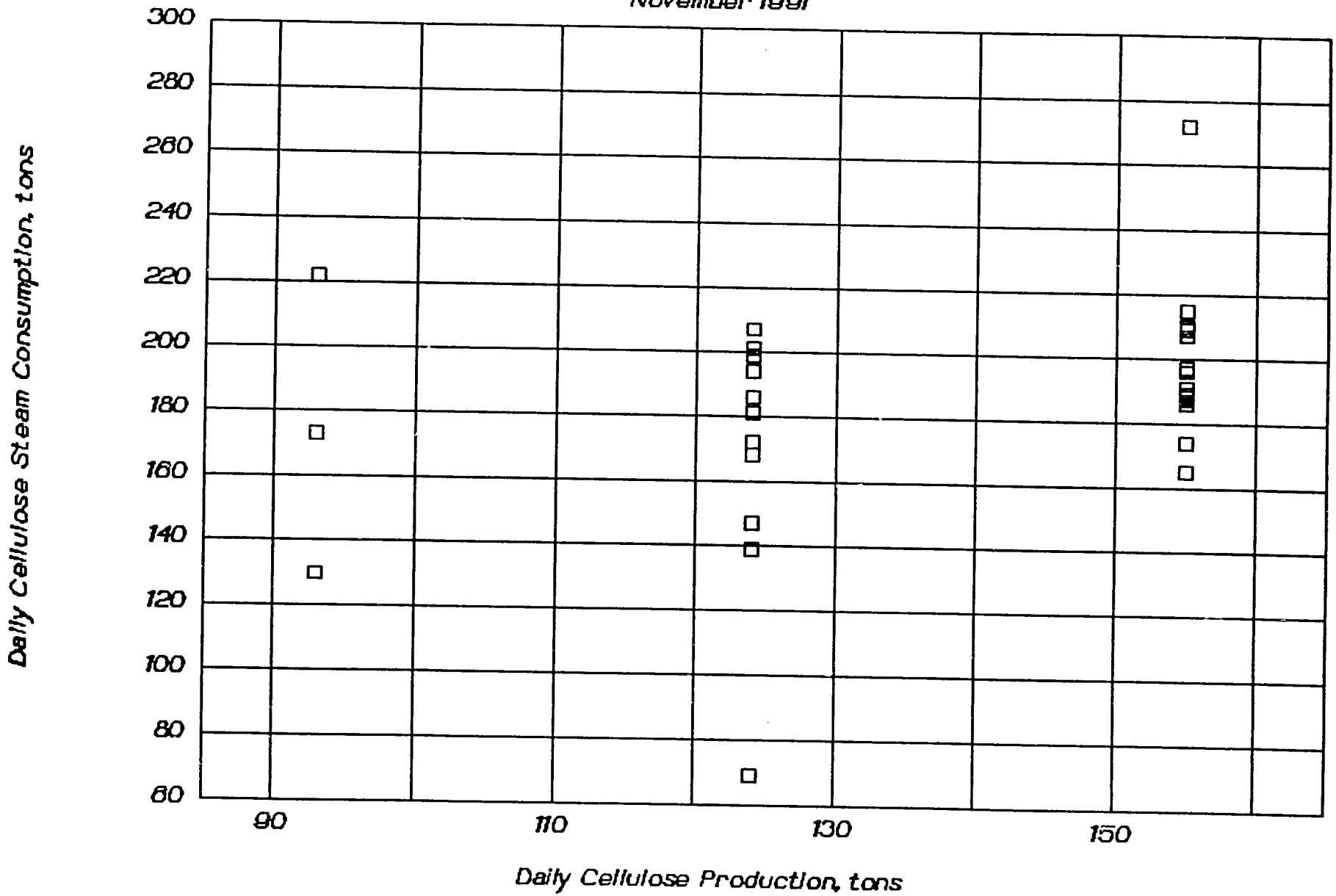

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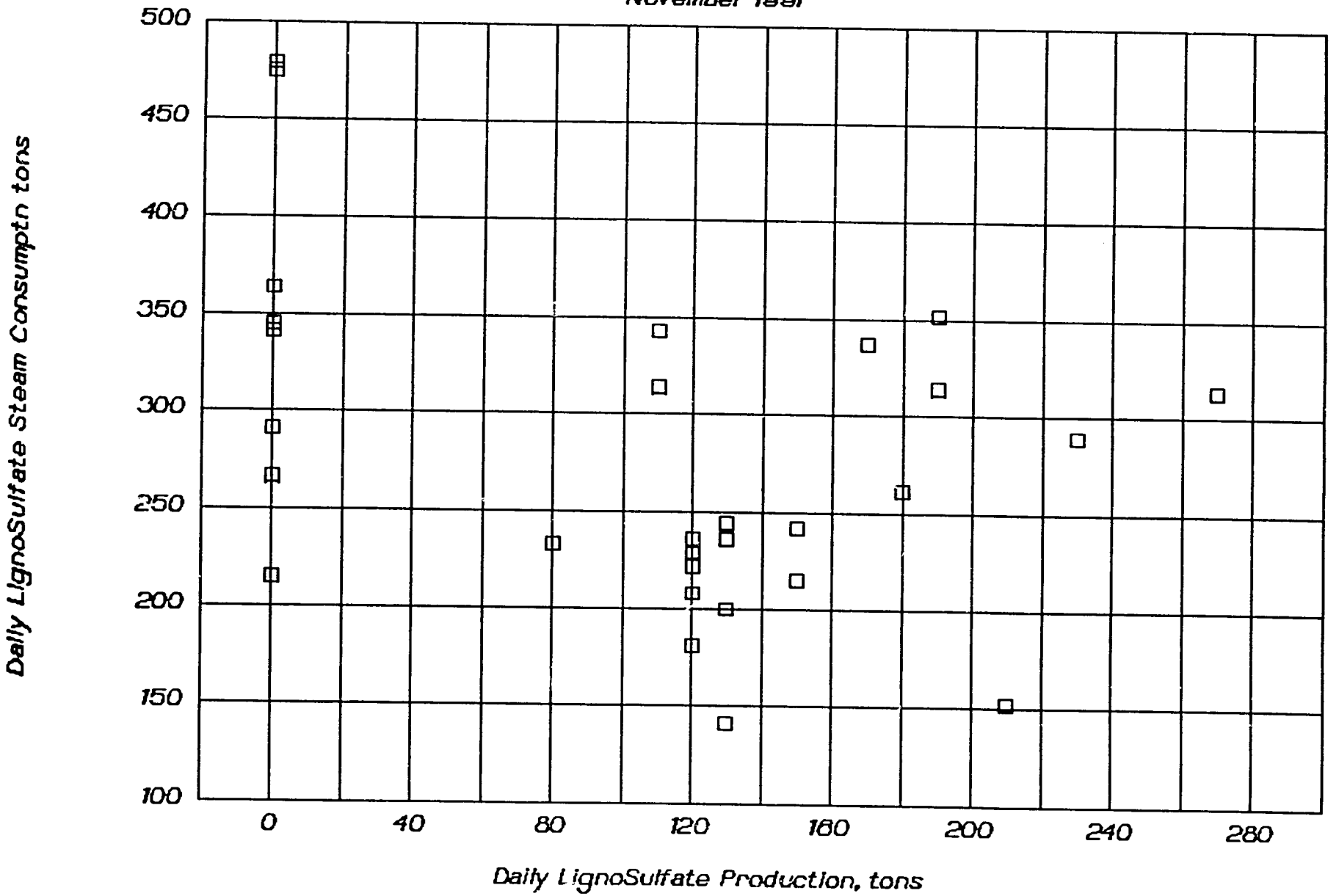

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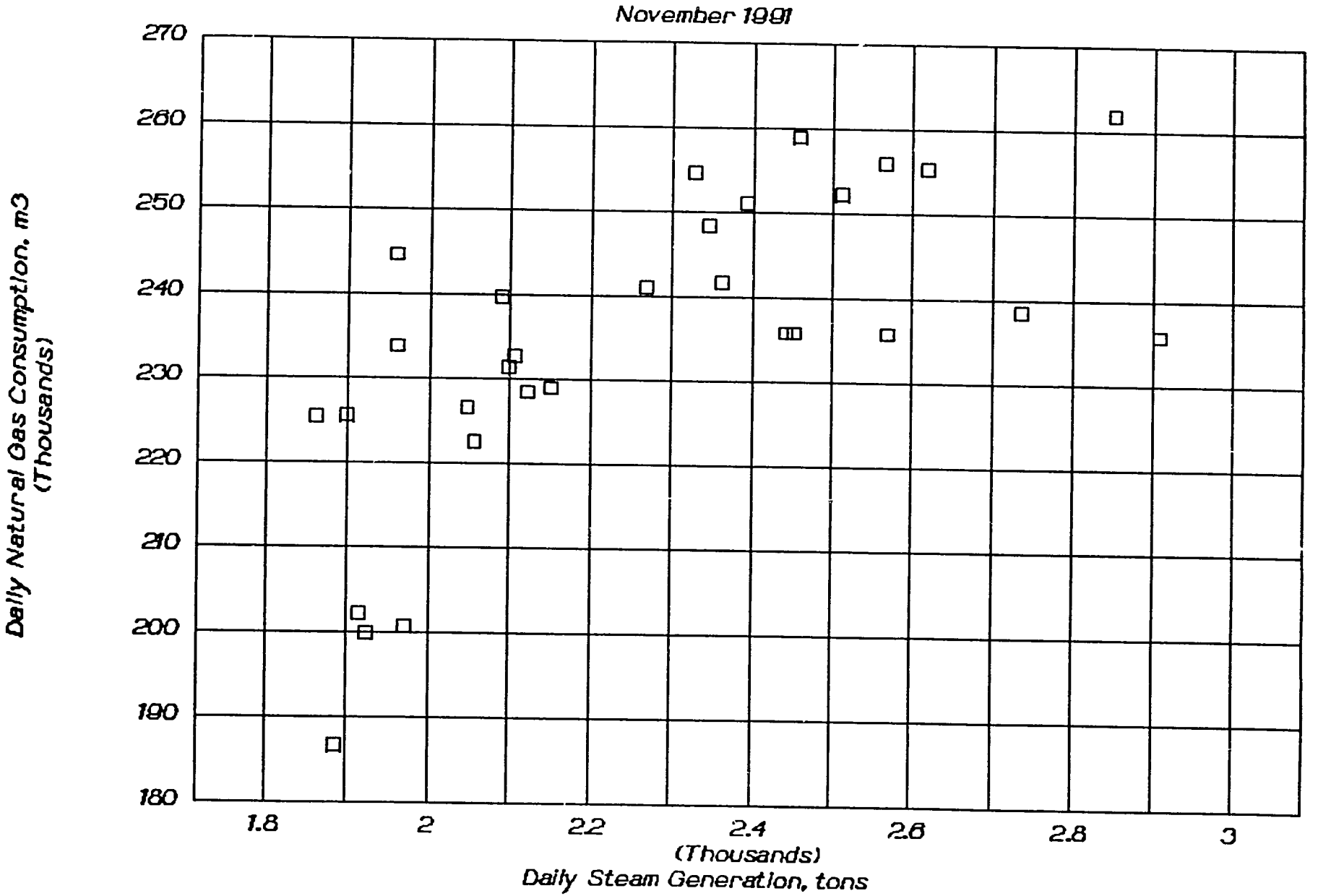
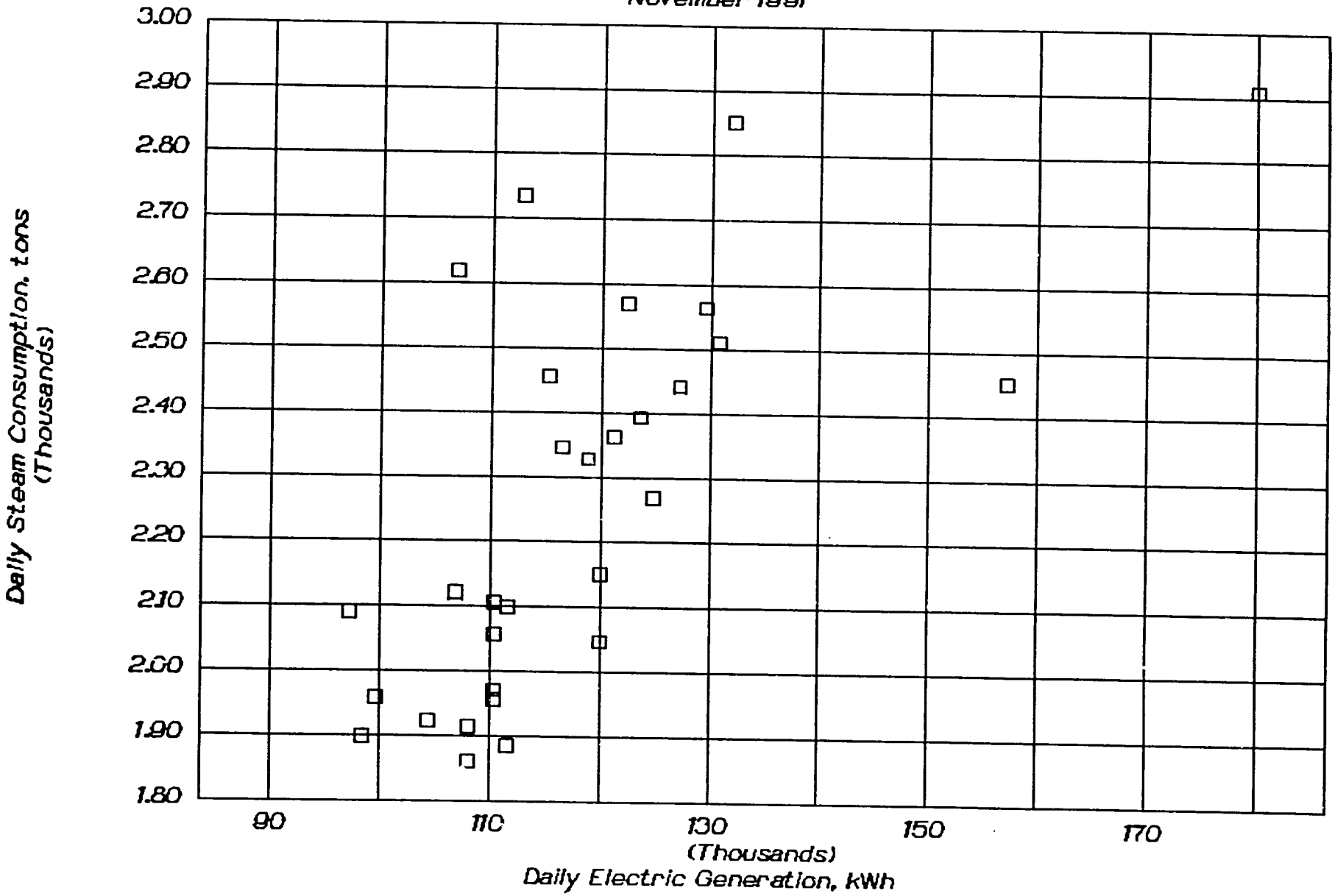


SLOKA PULP & PAPER - ENERGY/PRODUCTION

November 1991



SLOKAS CELULOZES UN PAPIRA FABRIKA (Pulp & Paper)

			Production			Consumption					Generation		Purchase
			Shop I	Shop II	Total	Gas 'm3	Gas Gcal	Elect kWh	Water m3	Air nm3	Steam ton	Elect kWh	Elect kWh
1988	1	1/88			9,738	8,546,000	72,641	13,465,000	1,824,000	2,496,000	94,387	6,588,000	6,877,000
	2				9,334	8,800,000	74,800	12,898,000	1,774,000	2,449,000	95,606	6,492,000	6,406,000
	3				9,146	9,201,000	78,209	13,397,000	1,843,000	2,524,000	102,438	6,756,000	6,641,000
	4				8,079	7,011,000	59,594	11,964,000	1,802,000	2,283,000	83,708	5,433,000	6,531,000
	5				9,219	7,093,000	60,291	13,202,000	1,897,000	2,479,000	78,771	5,182,000	8,020,000
	6				8,588	6,385,000	54,273	11,966,000	1,721,000	2,007,000	69,947	4,579,000	7,387,000
	7	7/88			7,159	5,430,000	46,155	10,456,000	1,424,000	2,308,000	62,096	3,538,000	6,918,000
	8				8,890	6,905,000	58,693	12,615,000	1,834,000	2,471,000	77,734	5,208,000	7,407,000
	9				9,139	6,668,000	56,678	13,051,000	1,727,000	2,319,000	75,247	5,140,000	7,911,000
	10				8,912	7,368,000	62,628	12,689,000	1,734,000	2,396,000	77,307	5,451,000	7,238,000
	11				8,370	7,566,000	64,311	12,621,000	1,694,000	2,580,000	82,153	5,333,000	7,288,000
	12				9,139	7,999,000	67,992	12,862,000	1,784,000	2,015,000	87,935	5,927,000	6,935,000
1989	1	1/89			8,147	7,920,000	67,320	12,633,000	1,672,000	2,078,000	87,720	6,279,000	6,354,000
	2				7,579	6,867,000	58,370	11,880,000	1,529,000	1,772,000	74,056	5,705,000	6,175,000
	3				8,158	7,240,000	61,540	12,239,000	1,661,000	2,185,000	79,166	5,705,000	6,534,000
	4				7,030	5,280,000	44,880	11,079,000	1,390,000	2,077,000	57,213	7,296,000	3,783,000
	5				7,974	5,744,000	48,824	11,645,000	1,458,000	2,380,000	65,231	4,078,000	7,567,000
	6				6,597	5,856,000	49,776	10,287,000	1,241,000	1,504,000	58,965	4,802,000	5,485,000
	7	7/89			7,013	5,580,000	47,430	9,515,000	1,117,000	1,342,000	57,550	4,510,000	5,005,000
	8				7,254	6,352,000	53,992	11,521,000	1,170,000	1,680,000	67,694	4,523,000	6,998,000
	9				7,682	6,285,000	53,423	11,320,000	1,180,000	2,111,000	65,827	5,131,000	6,189,000
	10				7,513	6,837,000	58,115	11,412,000	1,230,000	2,581,000	68,216	4,596,000	6,816,000
	11				7,061	7,003,000	59,526	11,131,000	0	2,297,000	71,781	4,926,000	6,205,000
	12				7,708	7,450,000	63,325	11,587,000	1,287,000	1,684,000	80,736	5,462,000	6,125,000
1990	1	1/90	2,646	2,770	6,065	7,189,000	61,107	10,681,000	1,179,000	2,600,000	74,447	5,346,000	5,335,000
	2		1,953	3,156	5,109	6,473,000	55,021	9,348,000	1,028,000	2,019,000	73,283	4,823,000	4,525,000
started new line/household pack			2,638	4,143	6,781	7,665,000	65,153	10,541,000	1,182,000	2,111,000	77,758	5,753,000	4,788,000
	4		2,615	3,977	6,592	6,416,000	54,536	10,936,000	1,344,000	2,001,000	72,047	4,734,000	6,202,000
closed for repairs			801	201	1,002	1,786,000	15,181	3,301,000	815,000	2,470,000	20,844	1,018,000	2,283,000
	6		1,660	1,765	3,425	5,047,000	42,900	8,129,000	1,043,000	1,911,000	51,165	2,719,000	5,410,000
	7	7/90	2,690	3,796	6,486	5,866,000	49,861	10,224,000	1,103,000	2,299,000	71,885	3,955,000	6,269,000
	8		2,322	2,949	5,271	4,956,000	42,126	10,009,000	1,119,000	2,246,000	66,115	3,532,000	6,477,000
	9		2,630	3,568	6,198	5,472,000	46,512	9,740,000	1,181,000	2,000,000	57,842	3,150,000	6,581,000
	10		2,493	2,581	5,080	5,928,000	50,385	9,671,000	1,193,000	2,319,000	59,907	3,235,000	6,436,000
	11		2,687	2,280	4,967	5,066,000	43,061	9,120,000	1,053,000	1,833,000	56,927	2,943,000	6,177,000
	12		2,455	2,509	4,125	5,783,000	49,156	9,012,000	1,086,000	1,917,000	61,261	2,914,000	6,098,000

SLOKAS CELULOZES UN PAPIRA FABRIKA (Pulp & Paper)

			Production			Consumption					Generation		Purchase
			Shop I	Shop II	Total	Gas 'm3	Gas Gcal	Elect kWh	Water m3	Air nm3	Steam ton	Elect kWh	Elect kWh
1991	1	1/91	2,550	3,546	6,096	6,669,000	56,687	9,871,000	1,111,000	2,655,000	71,131	3,432,000	6,439,000
	2		1,509	3,766	5,275	6,337,000	53,865	8,927,000	970,000	2,195,000	68,751	2,830,000	6,097,000
	3		2,953	3,772	6,725	6,338,000	53,873	11,299,000	1,251,000	2,054,000	69,496	3,733,000	7,566,000
	4		2,524	3,016	5,540	6,780,000	57,630	10,855,000	1,238,000	1,994,000	67,084	3,662,000	7,193,000
	5		2,977	3,110	6,087	5,785,000	49,173	11,356,000	1,291,000	1,976,000	63,658	3,255,000	8,101,000
	6		2,679	2,963	5,642	6,230,000	52,955	10,814,000	1,188,000	1,799,000	66,428	4,084,000	6,730,000
	7	7/91	1,508	2,241	3,749	2,839,000	24,132	6,886,000	678,000	1,028,000	29,791	1,428,000	5,458,000
	8		2,091	2,049	4,140	4,654,000	39,559	8,728,000	1,146,000	2,464,000	42,032	1,511,000	7,217,000
	9		2,862	1,701	4,563	5,471,000	46,504	9,467,000	1,148,000	2,058,000	49,105	1,706,000	7,761,000
	10		2,947	3,345	6,292	6,522,000	55,437	10,895,000	1,183,000	2,342,000	65,120	2,935,000	7,960,000
	11		2,681	2,802	5,979	7,033,000	59,781	11,211,000	1,183,000	2,040,000	74,500	3,544,000	7,667,000
	12												
Totals													
1988					105,713	88,972,000		151,186,000	21,058,000	28,327,000	987,329	65,627,000	85,559,000
1989					89,716	78,414,000		136,249,000	14,935,000	23,691,000	834,155	63,013,000	73,236,000
1990					61,101	67,647,000		110,712,000	13,326,000	25,726,000	743,481	44,131,000	66,581,000
1991					60,088	64,658,000		110,309,000	12,387,000	22,605,000	667,096	32,120,000	78,189,000
Monthly Averages													
1988					8,809	7,414,333		12,598,833	1,754,833	2,360,583	82,277	5,468,917	7,129,917
1989					7,476	6,534,500		11,354,083	1,244,583	1,974,250	69,513	5,251,083	6,103,000
1990					5,092	5,637,250		9,226,000	1,110,500	2,143,833	61,957	3,677,583	5,548,417
1991					5,463	5,878,000		10,028,091	1,126,091	2,055,000	60,645	2,920,000	7,108,091

SLOKAS CELULOZES UN PAPIRA FABRIKA (Pulp & Paper)
DAILY PERFORMANCE
NOVEMBER 91

	PRODUCTION PAPER #1 tons	PAPER #2 tons	PAPER total	CELLULOSE tons	MECH PULP tons	LIGNOSULFATE tons
1	134	179	313	155	27	180
2	55	124	179	124	20	150
3	122	116	238	124	17	120
4	103	117	220	124	22	120
5	108	57	165	124	10	0
6	39	98	137	124	20	150
7	125	82	207	155	27	80
8	104	41	145	124	27	130
9	62	109	171	93	28	120
10	89	157	246	155	28	120
11	90	130	220	124	28	120
12	74	41	115	93	21	0
13	88	138	226	155	21	130
14	76	116	192	93	2	230
15	72	177	249	155	25	130
16	78	52	130	155	22	110
17	67	46	113	155	15	190
18	99	167	266	155	29	170
19	108	99	207	124	13	190
20	110	54	164	155	23	270
21	255	7	262	155	13	210
22	193	0	193	124	26	130
23	234	0	234	155	19	110
24	230	0	230	155	15	0
25	261	28	289	155	22	0
26	147	11	158	155	22	0
27	126	0	126	155	13	0
28	139	140	279	124	15	0
29	4	52	56	155	12	0
30	0	0	0	124	0	0
TOTAL	3,392	2,338	5,730	4,123	582	3,160
AVERAGE	113.1	77.9	191.0	137.4	19.4	105.3

SLOKAS CELULOZES UN PAPIRA
DAILY PERFORMANCE
NOVEMBER 91

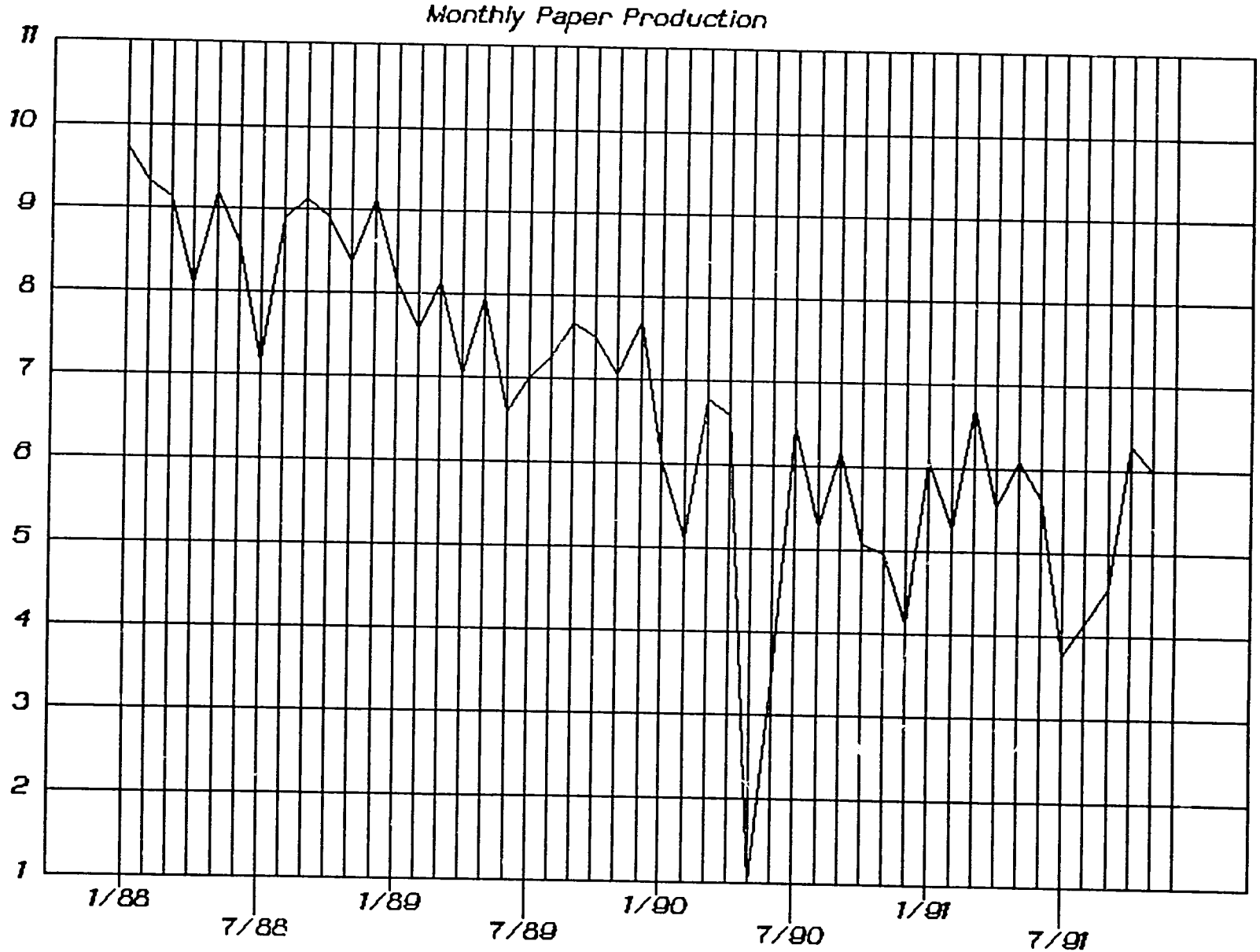
	ENERGY - ELECTRICITY LATVENERGO PURCHASE kWh	SELF-GENERATION #1 kWh	#2 kWh	TOTAL kWh	USAGE kWh	ENERGY GAS USAGE m3	ENERGY STEAM GENERATION K-6 tons	K-7 tons	K-8 tons	TOTAL tons
1	297,072	0	106,800	106,800	403,872	255,278	0	1,156	1,462	2,618
2	246,680	0	115,200	115,200	361,880	258,935	0	1,173	1,284	2,457
3	275,448	0	110,400	110,400	385,848	244,683	717	1,240	0	1,957
4	256,860	0	111,600	111,600	368,460	186,663	709	1,176	0	1,885
5	270,760	2,400	117,600	120,000	390,760	226,503	836	1,211	0	2,047
6	269,864	0	98,400	98,400	368,264	225,490	765	1,133	0	1,898
7	292,840	0	108,000	108,000	400,840	202,300	796	1,118	0	1,914
8	334,032	0	111,600	111,600	445,632	231,381	925	1,174	0	2,099
9	328,028	0	110,400	110,400	438,428	222,501	945	1,111	0	2,056
10	314,428	0	106,800	106,800	421,228	228,488	945	1,177	0	2,122
11	278,672	0	108,000	108,000	386,672	225,375	783	1,077	0	1,860
12	273,720	0	110,400	110,400	384,120	200,841	861	1,110	0	1,971
13	306,076	0	110,400	110,400	416,476	232,681	925	1,180	0	2,105
14	264,200	0	99,600	99,600	363,800	233,845	866	1,093	0	1,959
15	278,981	0	104,400	104,400	383,381	199,988	749	1,174	0	1,923
16	274,139	0	124,800	124,800	398,939	241,128	981	1,288	0	2,269
17	276,716	0	121,200	121,200	397,916	241,775	1,028	1,334	0	2,362
18	275,480	0	118,800	118,800	394,280	254,598	985	1,343	0	2,328
19	289,655	0	116,400	116,400	406,055	248,456	1,027	1,319	0	2,346
20	286,864	0	120,000	120,000	406,864	228,989	936	1,215	0	2,151
21	299,452	0	97,200	97,200	396,652	239,779	790	1,300	0	2,090
22	304,476	0	112,800	112,800	417,276	238,646	0	1,237	1,499	2,736
23	300,360	0	129,600	129,600	429,960	256,037	0	1,202	1,363	2,565
24	285,024	0	123,600	123,600	408,624	251,173	0	1,189	1,204	2,393
25	288,216	0	130,800	130,800	419,016	252,300	0	1,159	1,352	2,511
26	255,388	10,800	121,200	132,000	387,388	261,795	0	1,273	1,577	[illegible]850
27	247,328	104,400	75,600	180,000	427,328	235,843	0	1,318	1,590	2,[illegible]8
28	306,496	73,200	84,000	157,200	463,696	235,843	0	1,196	1,256	2,45[illegible]
29	322,664	0	122,400	122,400	445,064	235,843	0	1,185	1,385	2,570
30	303,750	0	127,200	127,200	430,950	235,843	0	1,235	1,207	2,442
TOTAL	8,603,669	190,800	3,355,200	3,546,000	12,149,669	7,033,000	16,569	36,096	15,179	67,844
AVERAGE	286,789	6,360	111,840	118,200	404,989	234,433	552	1,203	506	2,261

SLOKAS CELULOZES UN PAPIRA FABRIKA (Pulp & Paper)
DAILY PERFORMANCE
NOVEMBER 91

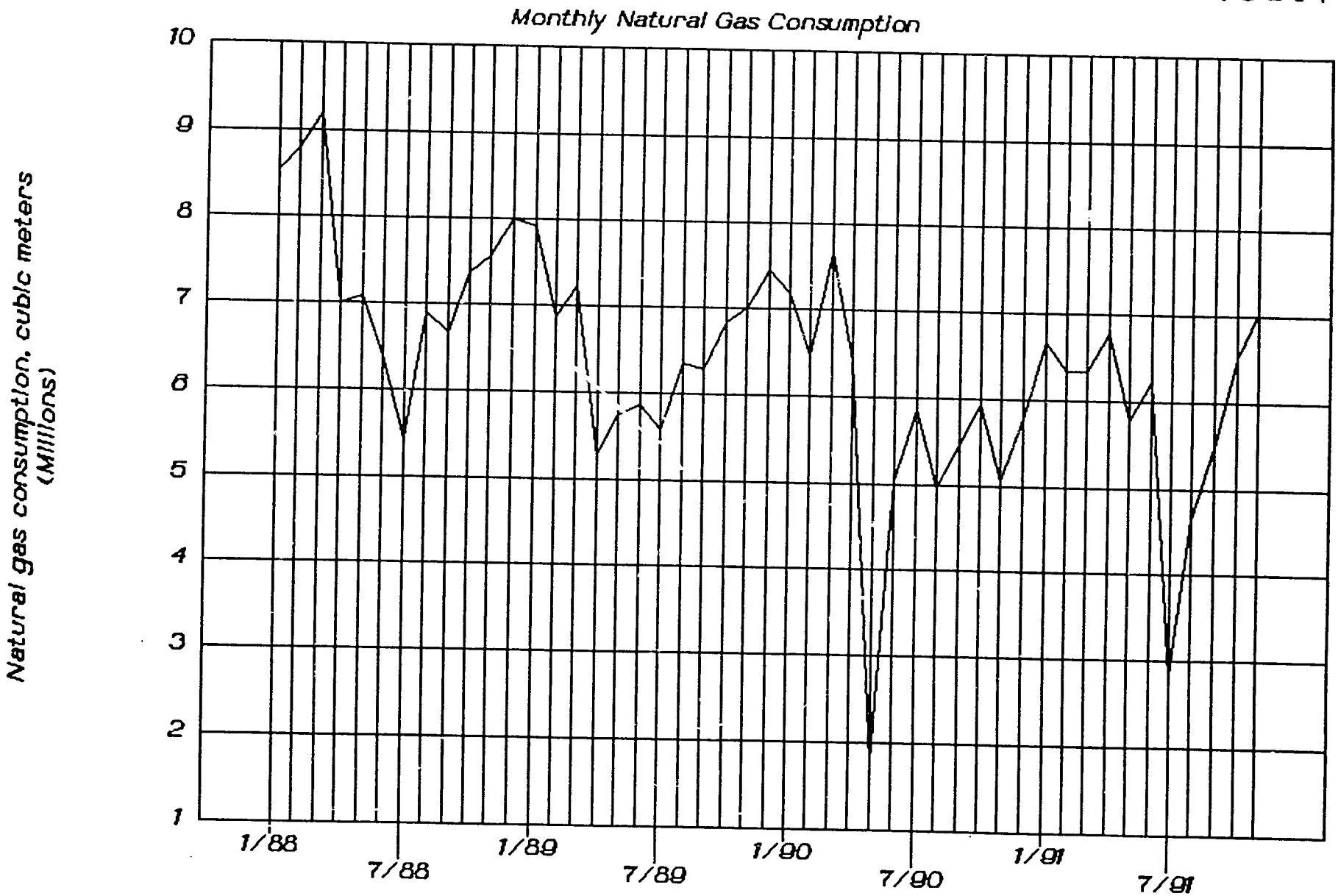
STEAM CONSUMPTION

	PAPER #1 Gcal	PAPER #2 Gcal	PAPER total	CELLULO Gcal	LIGNOS Gcal
1	215	315	530	165	261
2	176	83	259	139	242
3	262	237	499	162	229
4	204	223	427	172	181
5	266	176	442	207	266
6	173	266	439	201	215
7	200	235	435	189	233
8	243	345	588	147	236
9	221	269	490	173	222
10	234	275	509	215	208
11	199	268	467	69	236
12	198	214	412	222	215
13	239	345	584	196	200
14	202	161	363	130	289
15	280	234	514	186	141
16	274	312	586	187	343
17	270	402	672	188	352
18	250	320	570	210	337
19	281	345	626	181	314
20	275	213	488	197	313
21	292	356	648	174	152
22	281	348	629	186	244
23	291	352	643	197	314
24	298	380	678	191	266
25	267	337	604	197	291
26	288	307	595	209	345
27	232	340	572	207	364
28	296	328	624	199	341
29	279	306	585	272	479
30	308	397	705	194	475
TOTAL	7,494	8,689	16,183	5,568	8,304
AVERAGE	250	290	539	186	277

SLOKA PULP & PAPER - PRODUCTION



SLOKA PULP & PAPER - ENERGY CONSUMPTION



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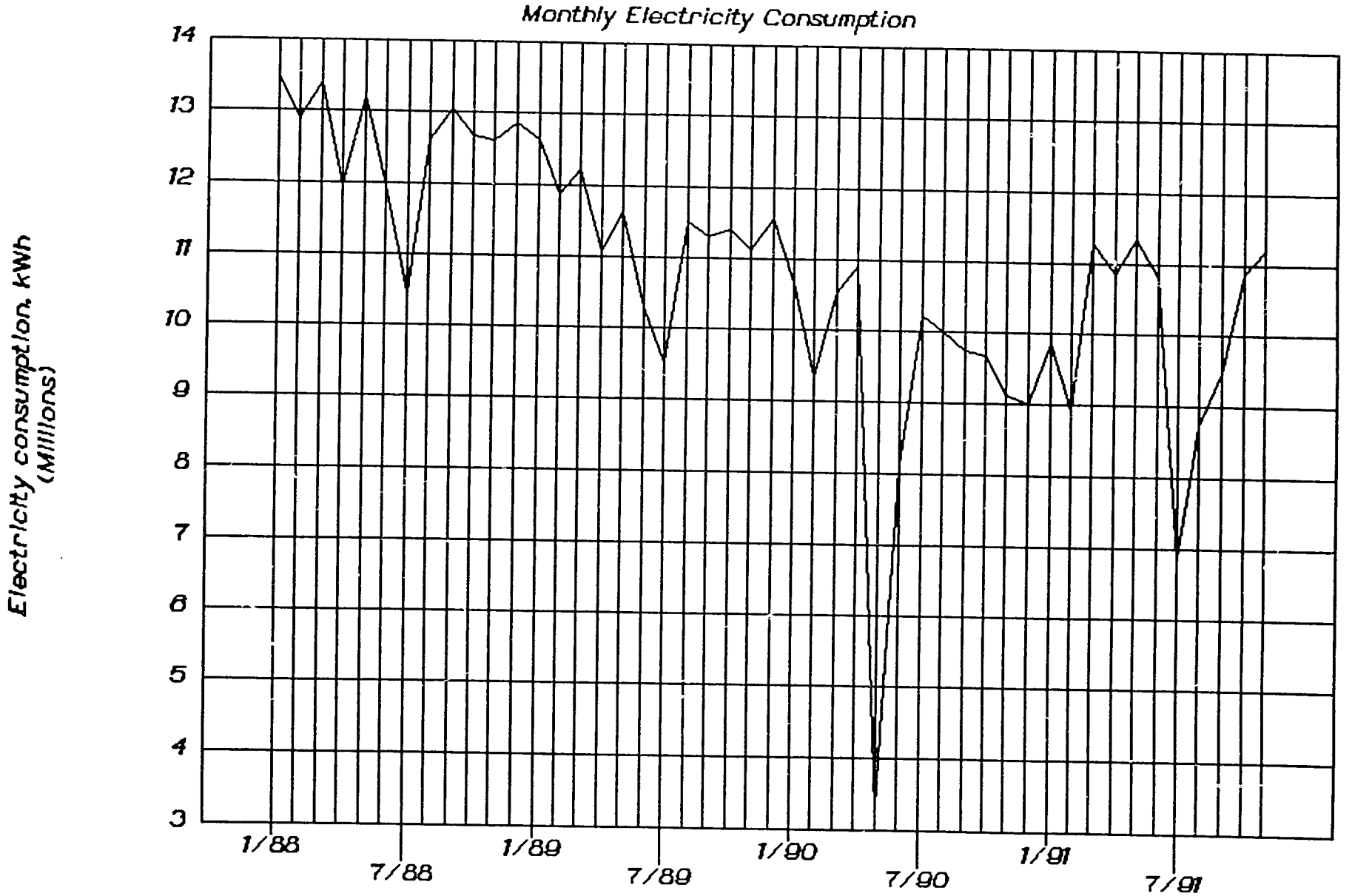

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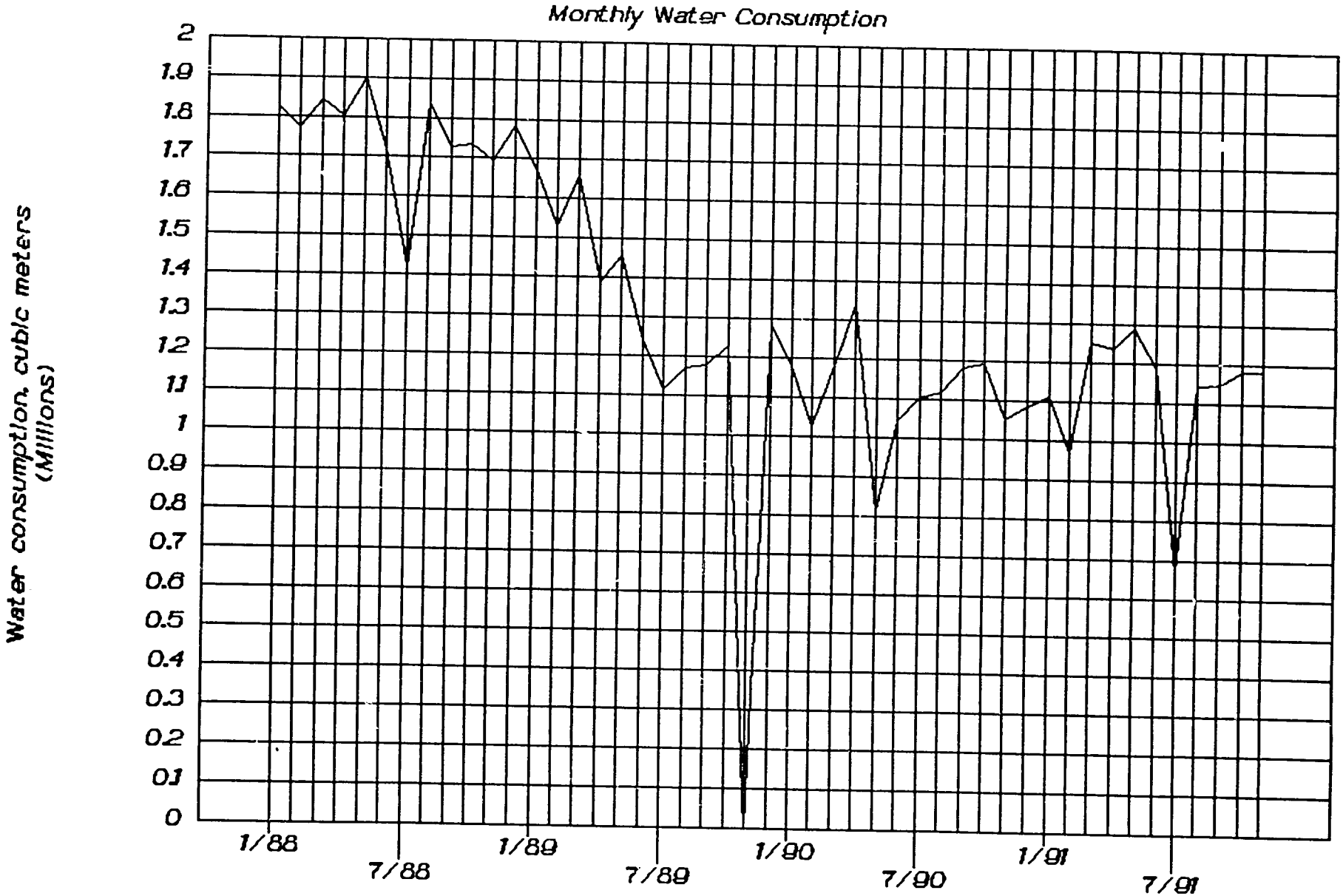

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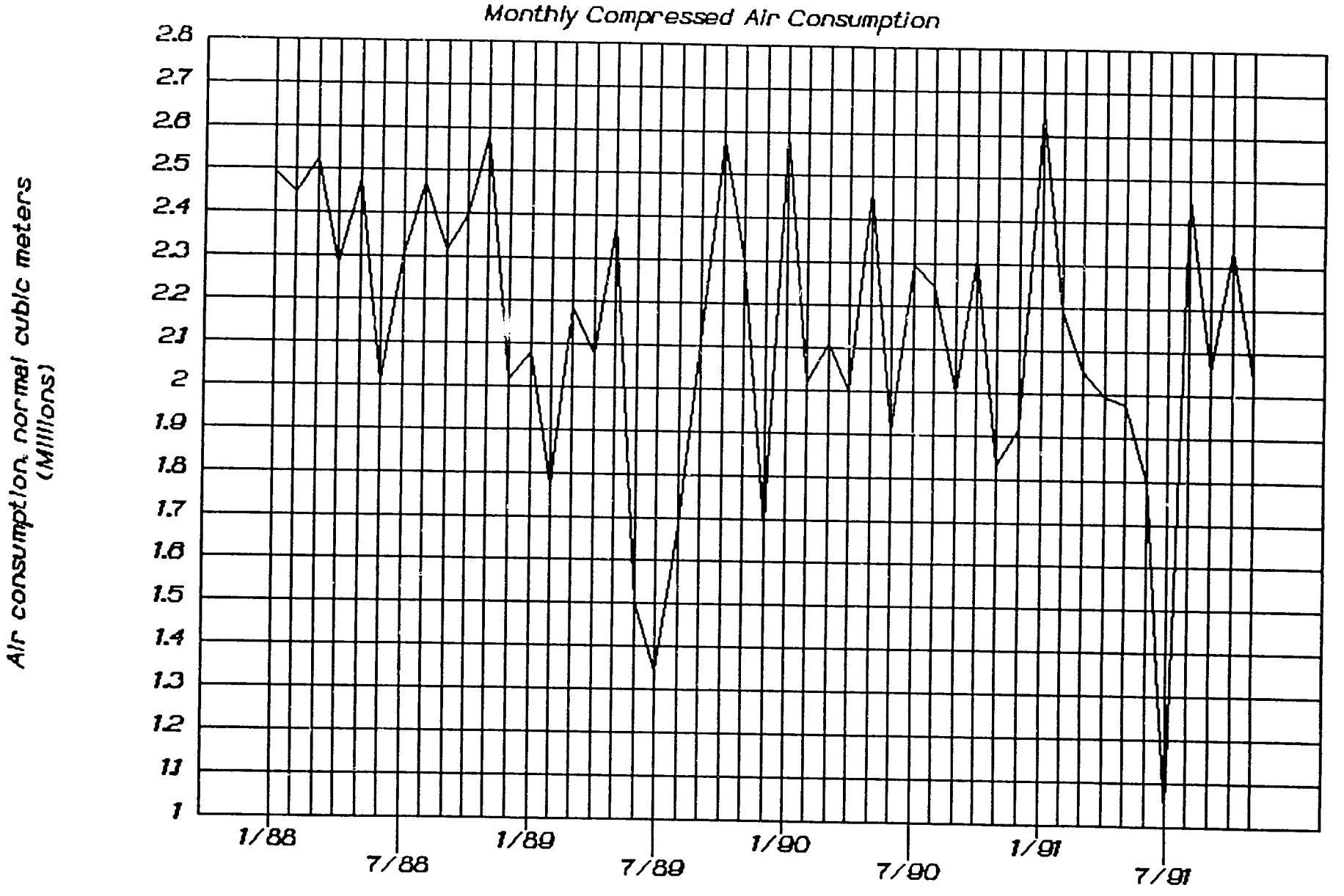

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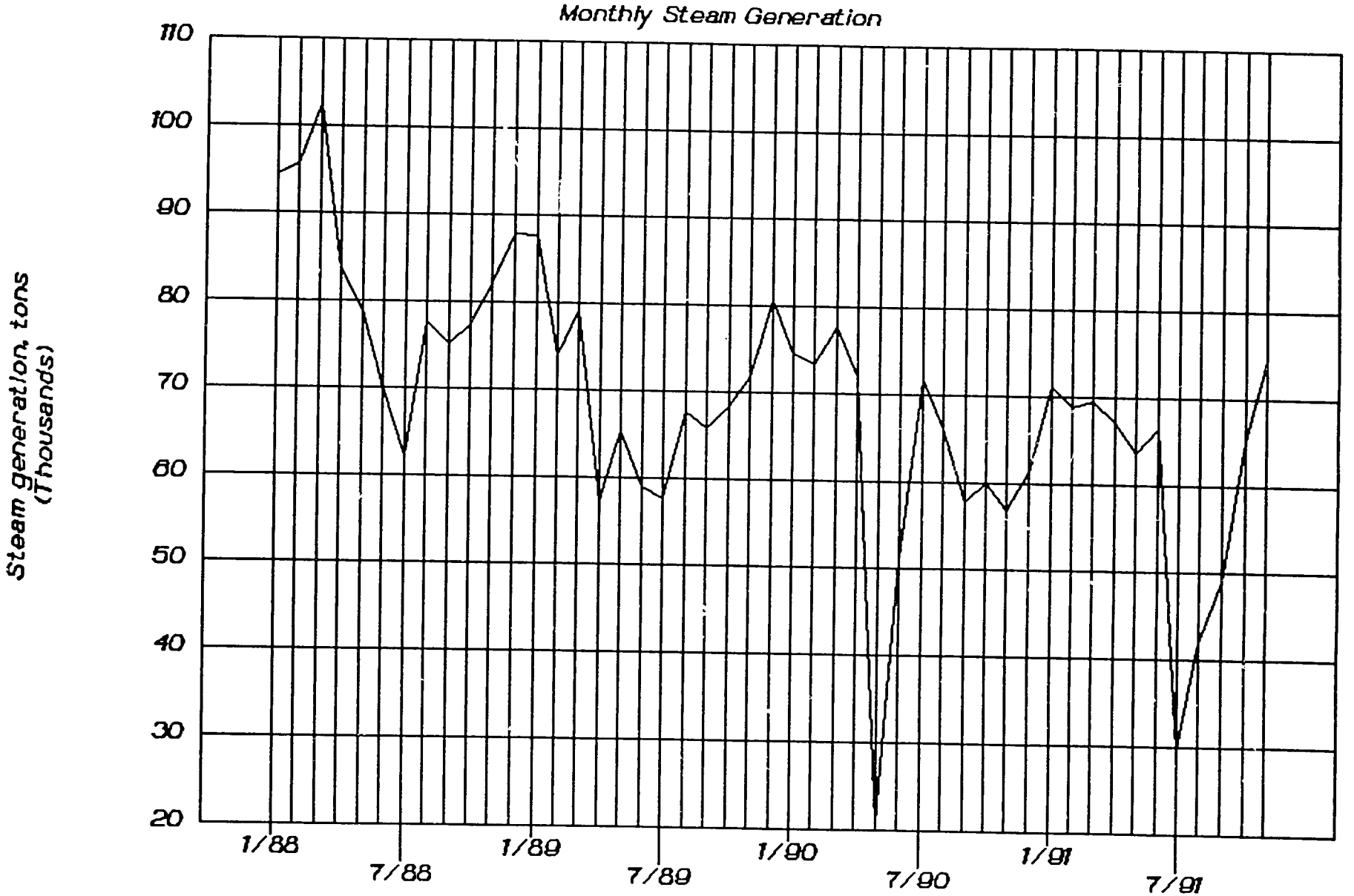

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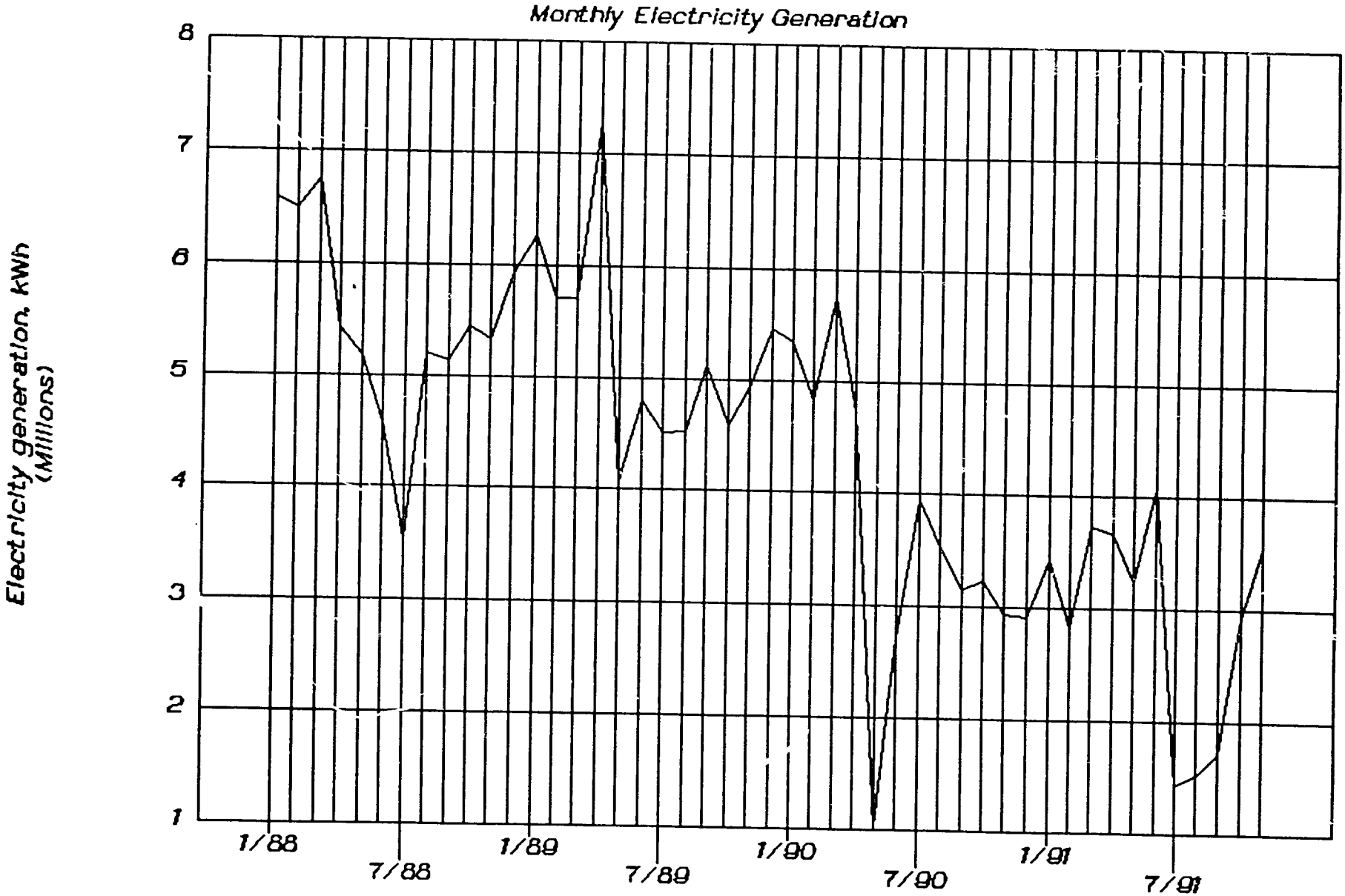

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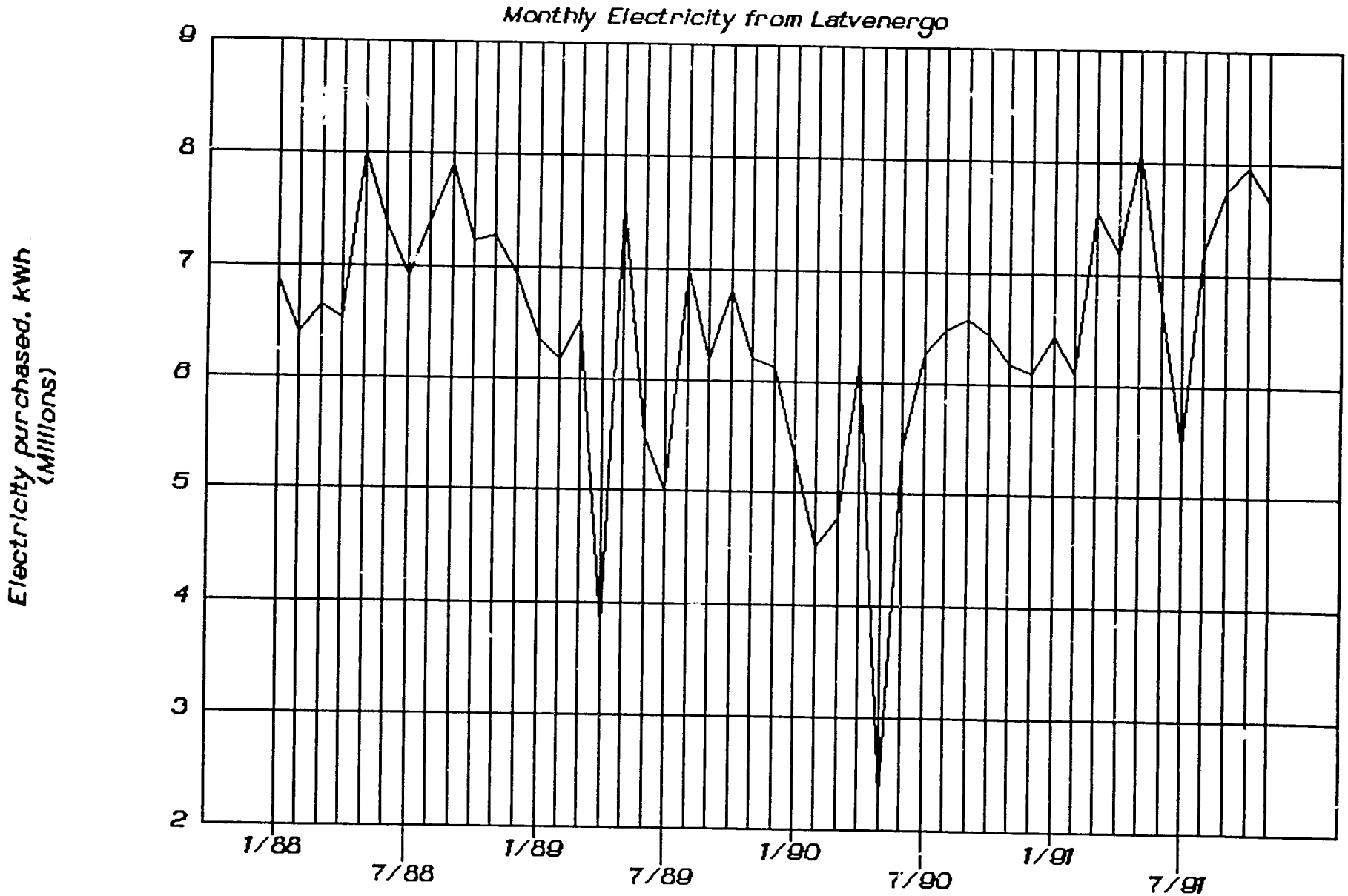

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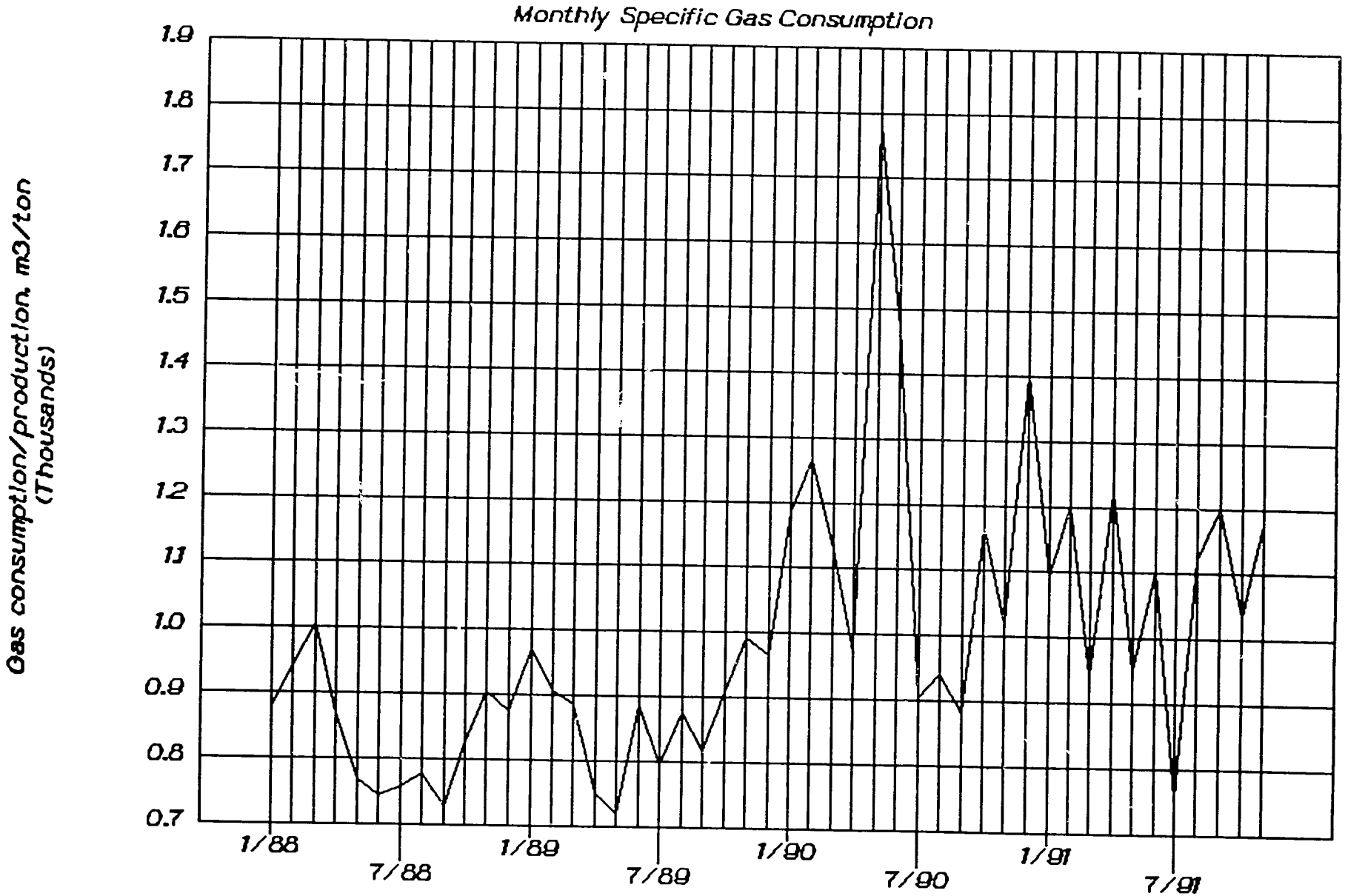

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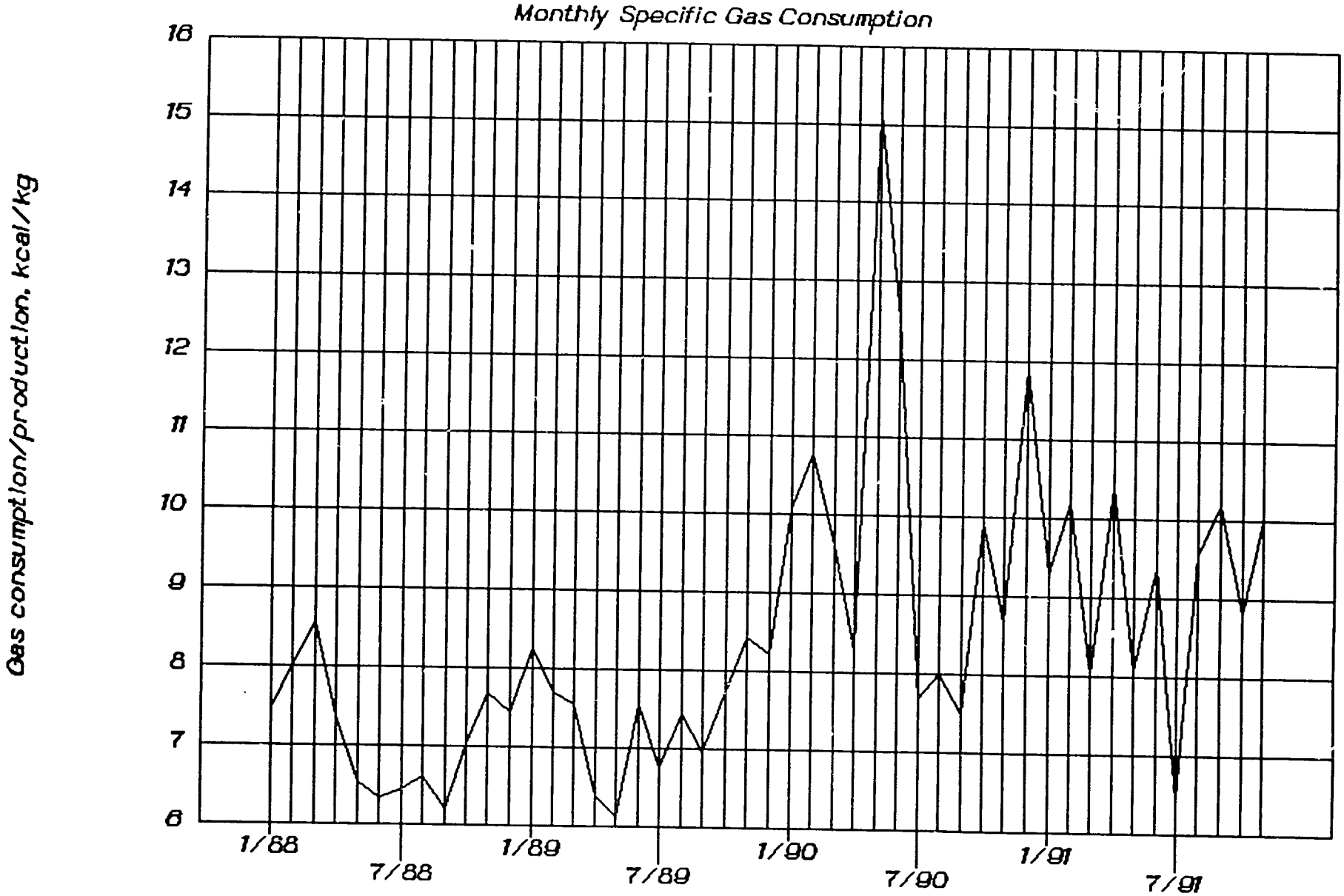

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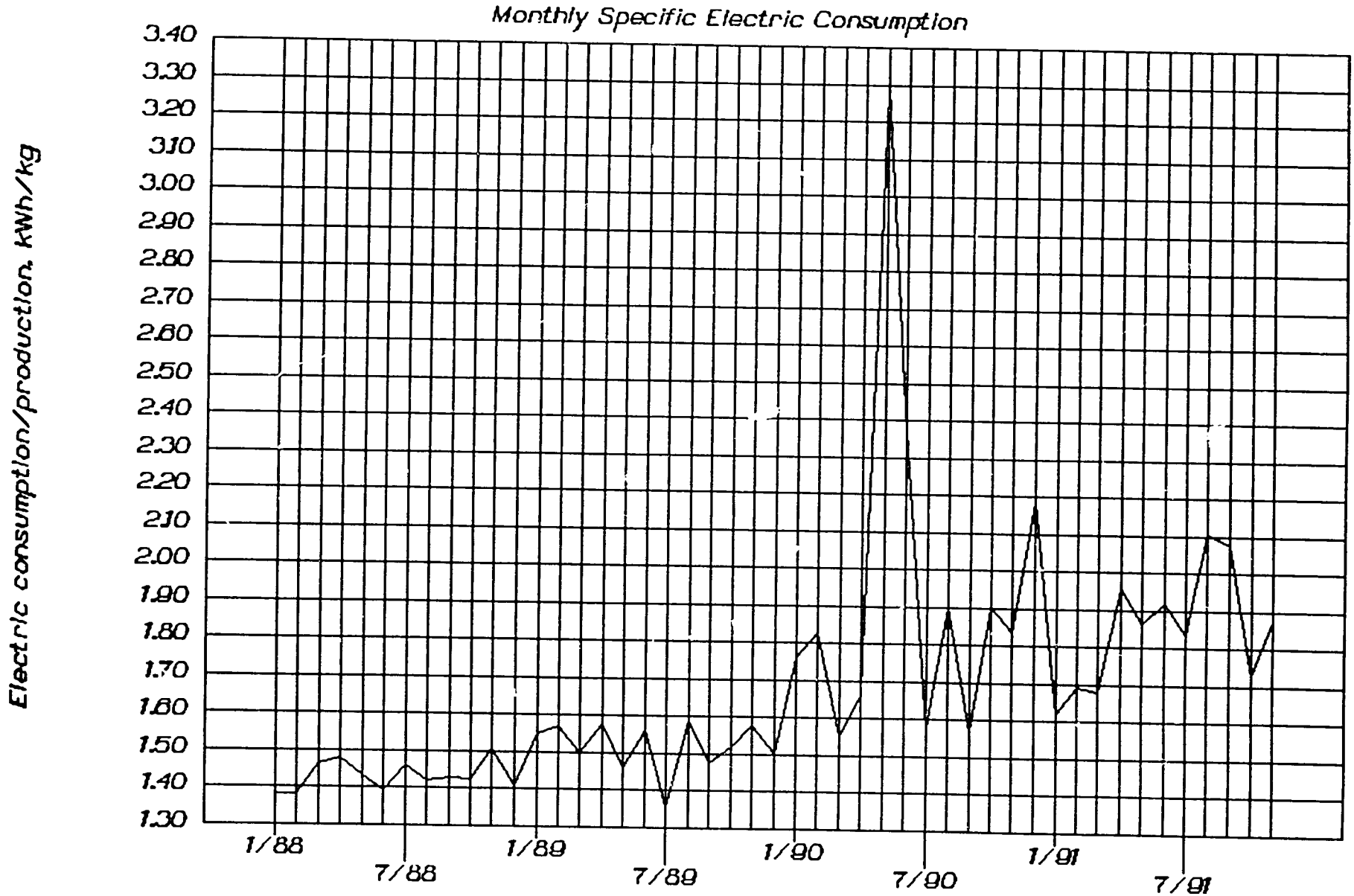

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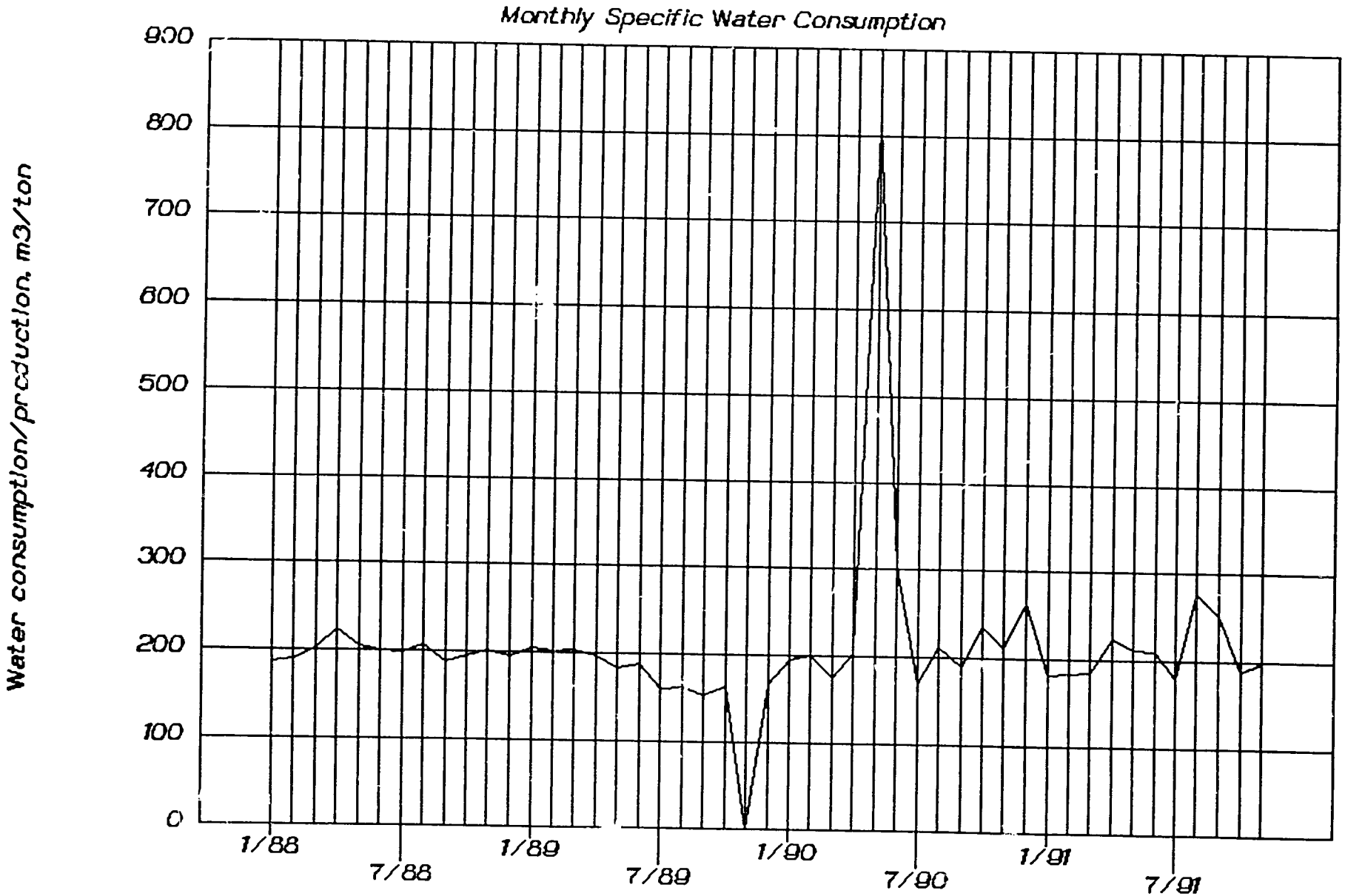

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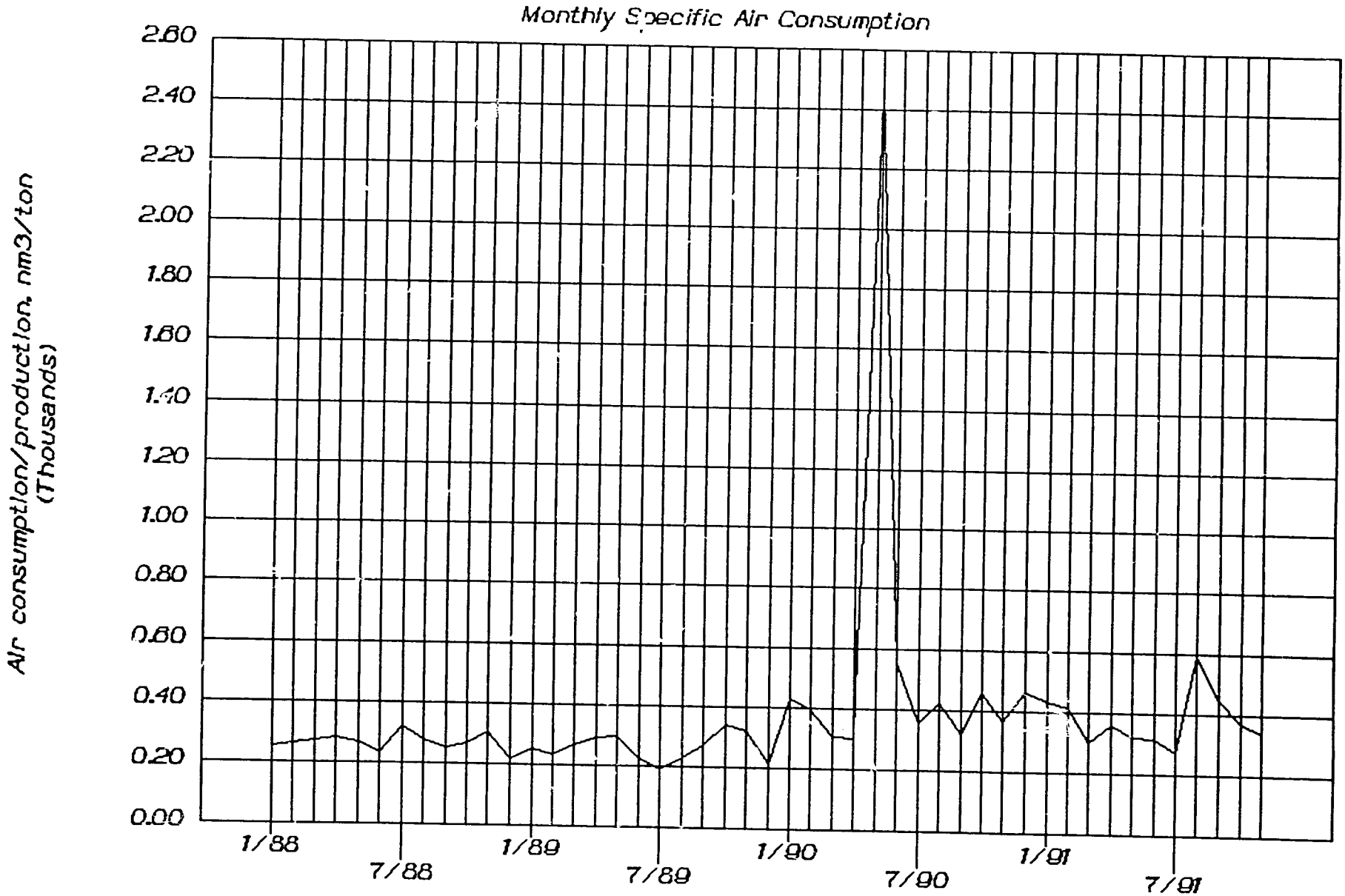

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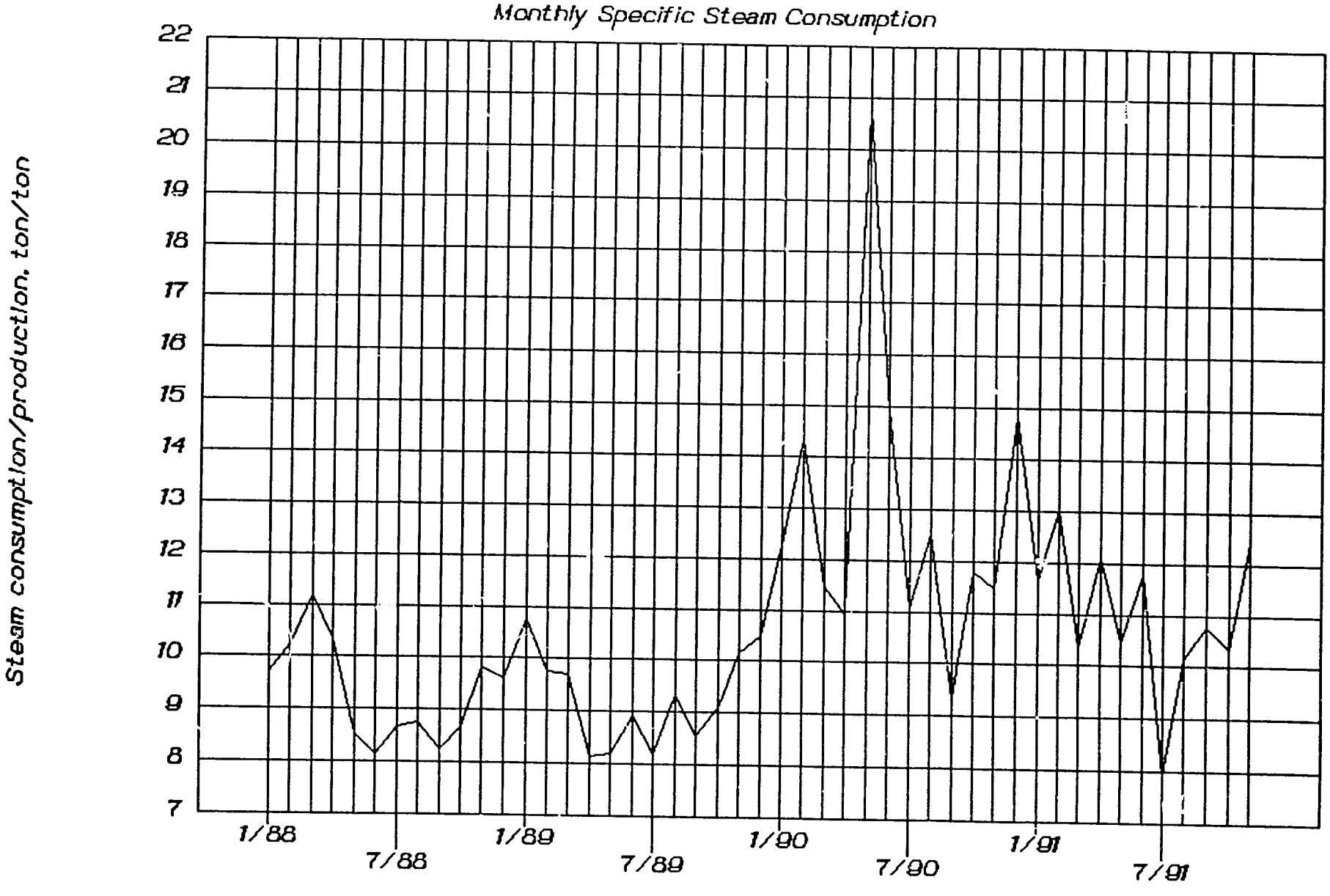
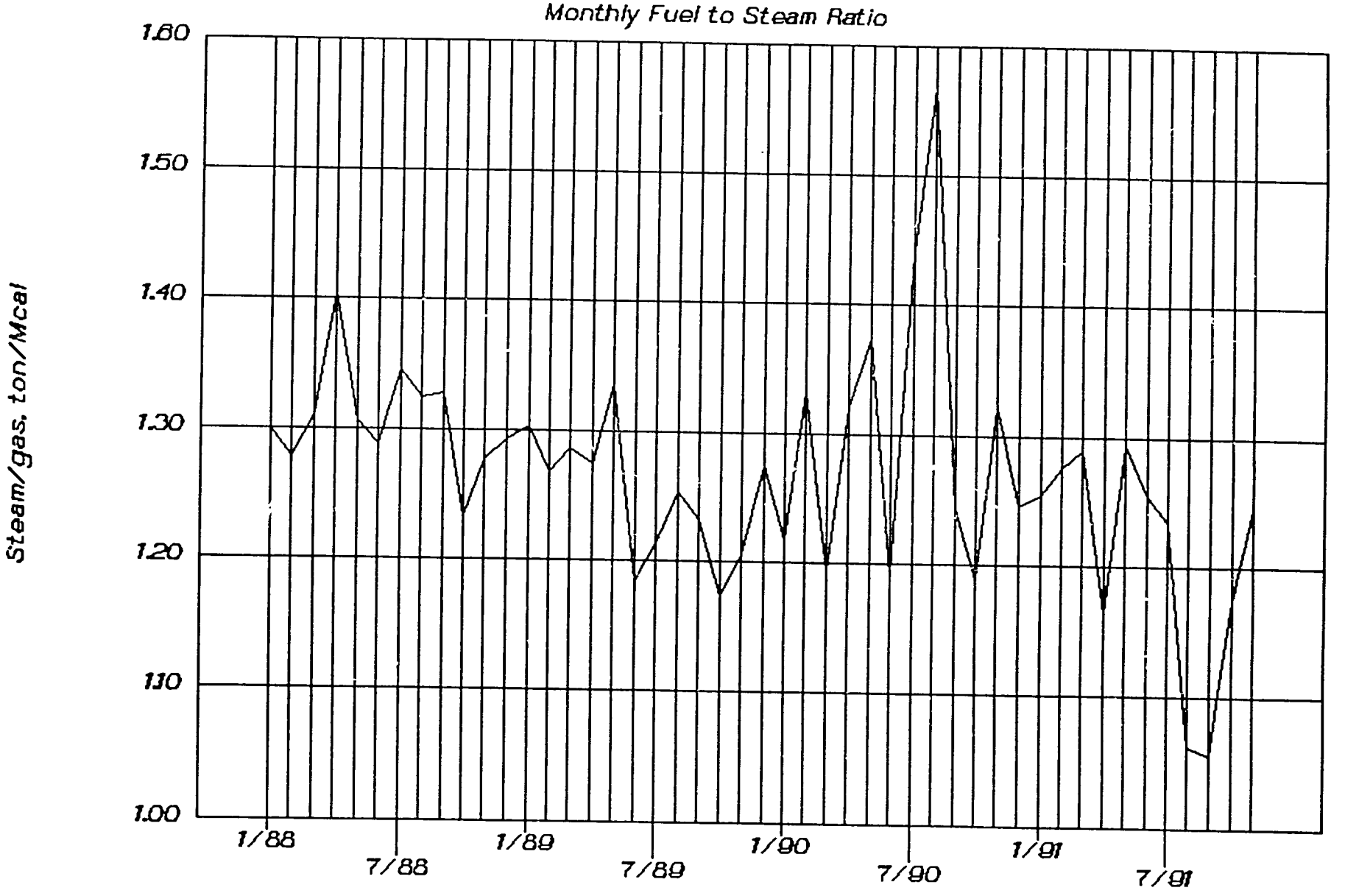
SLOKA PULP & PAPER - ENERGY EFFICIENCY