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ENERGY EFFICIENCY AUDIT REPORT
CSEPEL MUVEK FEMMU METALWORKS PLANT
BUDAPEST, HUNGARY

MARCH 1992

PREPARED BY: RCG/HAGLER, BAILLY, INC.
Arlington, VA

and

EGI CONTRACTING & ENGINEERING
Budapest, Hungary

U.S. EMERGENCY ENERGY PROGRAM FOR EASTERN AND CENTRAL EUROPE

U.S. AGENCY FOR INTERNATIONAL DEVELOPMENT
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QUALITY ASSURANCE STATEMENTS

The contents of this report include recommendations based on data provided by the client plant, measurements made on site, calculations, and engineering judgement. The conclusions reached were based on a limited engagement of only about one week's duration in the plant, 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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EXECUTIVE SUMMARY

This report is a result from a preliminary energy audit carried out by a team of engineers from RCG/Hagler,Bailly and EGI Contracting & Engineering between March 13 and March 19, 1991 at the Csepel non-ferrous metals plant (CSEPEL).

In addition to the team, RCG/Hagler,Bailly provided a complete set of portable instruments to conduct on-site measurements. EGI provided all facilities for logistic support, including meeting arrangements and translation services.

Given the scope of the assignment and resources available, it was decided to focus the audit on sectors and subjects considered as a priority by the plant management. This means that extensive and thorough efforts were developed by the audit team to reach visible and short-term implementable results related to the points of focus. Beyond the focus points, all activities and analysis as part of a preliminary energy audit were covered by the audit team. In addition, the approach and methodology were adapted to provide a continuous training to counterparts of the audit team in the plant.

The areas of focus of the energy audit were (1) the energy efficiency of process section such as copper refining, copper electrolysis, continuous casting, and (2) energy management improvement.

In 1990, CSEPEL purchased an amount of energy equivalent to 48,000 tons of oil equivalent, expressed in primary energy. 71% of that primary energy demand consisted of electricity, the remaining 29%, consisted of heat under the form of steam, gas and hot water.

If that energy was to be imported to Hungary at the international market price ($20 per barrel of oil), the cost would be about 6.7 million US$ in hard currency. Using the current price of energy (March 1991), the actual energy bill paid by CSEPEL is worth 554 million Forints.

The major recommendation of the audit is that CSEPEL needs to implement an energy measurement and conservation program for steam, hot water and compressed air, similar to the program done for electricity. Potential for savings for these three utilities is between 20% and 30%. Furthermore, because of price distortion we recommend that CSEPEL stops steam purchase from the power company and replaces it with natural gas or heat recovery.

Further savings could be achieved by rationalizing the production and implementing a computerized manufacturing resources planning and control program.

By implementing the aforementioned recommendations, CSEPEL should expect annual savings between 40 and 60 million Forint.

List of candidate equipment which could be procured by USAID as part of the Emergency Efficiency Program

Action	Equipment	Cost in US $	Total energy savings U S $ / y e a r
A.1	Terminals for EMS system (3)	$25,000	$110,000
A.2	Electrical harmonic analyzer	$15,000	$ 70,000
A.3	Ultrasonic tester	$ 2,000	$ 58,000
A.4	Infrared thermal imager and thermometer	$17,000	$ 97,000

Given the level of funding available, RCG/Hagler, Bailly recommends that only items A.1 and A.2 be procured under the U.S.A.I.D. program. Both of these items relate to industrial process aspects, rather than the supply of utilities (A.3 relates to compressed air and A.4 relates to building heat). Items A.1 and A.2 offer the opportunity for increased benefits other than just energy savings, such as improved productivity or quality through process control (A.1) and reduced electrical system maintenance costs (A.2).

1. INTRODUCTION TO THE PLANT

1.1 Description of the Plant and activities

Csepel Metalworks is producing non-ferrous products (copper and aluminium based) and steel products under the form of strips, sheets, wires, rods or cables. Annual production is roughly 10,000 tons of non-ferrous strips (nearly at capacity rate), 12,000 tons of rods and tubes (nearly at capacity rate), 22,000 tons of wires and cables (capacity is 34,000 t) and 2,000 to 3,000 of miscellaneous products which are made from additional processing of the aforementioned products. Roughly half of the production is exported (on dollar basis) and half is for the local market. Csepel Metalworks was formerly part of a metallurgical conglomerate located on the island of Csepel with its own power station. In 1983, the conglomerate was divided into 11 companies including Csepel Metal Works and the power plant which supplies electricity, steam, hot water and compressed air to Csepel Metalworks. It is difficult to distinguish between these 11 companies in geographic terms, as there are no physical barriers. In terms of energy accounting, the problem is quite tricky, because there are dozens of electricity meters as opposed to just one. Even within an electrical substation, part of the equipment may belong to the power plant and part of it may belong to Csepel. To make it even more complex, Csepel has installed, at its own cost, electrical meters on equipment belonging to the power station and, as a result, has no access to them for maintenance.

Csepel Metalworks employs 2000 people working in three or four shifts.

1.1.1 Process areas

The plant located in Csepel consists of three production divisions, each one being subdivided into departments with their own account numbers. In the following list, the numbers in parenthesis indicate the current account number.

- Copper Metallurgy division
  - **Refining (411)**
  - **Electrolysis (412)**
  - Vacuum casting (414)
  - Dip forming (419) - bought from General Electric 12 years ago
  - Aluminium casting (421)

- Rolling mill division
  - Steel rolling mill (511)
  - Steel strength annealing treatment (512)
  - Protective gas production (513)
  - Strip rolling mill (514)
  - Hydrogen furnace (515)
  - Sheet plant (517)
  - Steel plant furnace (519)
  - Metal casting plant (516)
- Cold drawing division
  - Wire drawing (615)
  - Pickling (616)
  - 3500 t and 1500 t press (611)
  - 630 t press (612)
  - 2000 t press (613)
  - Wire rolling (617)
  - Tube and rod drawing (614)
  - **Continuous casting (618)**

The departments written in bold face characters have received a special focus of interest during the Preliminary Energy Audit.

1.1.2 Copper refining department

The copper refining department consists of three furnaces, a flue gas conditioning plant and a carousel for casting anodes.

The raw material is usually scraps from other departments, such as residual anodes from the electrolysis plant. Blister copper purchased on the international market may be processed. The opportunity for processing blister copper depends on its price.

Raw materials are loaded into a vertical shaft furnace fired with natural gas (4 burners) to be melted. Melted copper is loaded by gravity on the second furnace while slags are removed from the vertical shaft. The second furnace is an oxidizing furnace: compressed air is injected into the melted copper to remove impurities. A radiant air preheater preheats the combustion air of the unique burner of this furnace up to 200° C. Then, melted copper is tapped to the third furnace. There, a reduction operation is performed by sticking a long piece of wood in the melted copper. After this purification process, copper is cast into an anode shape to be used in the electrolysis department.

1.1.3 Continuous casting department

This department produces strips of alloys for lines of horizontal continuous casting mills.

Alloys are prepared and melted in induction furnaces.

1.1.4 Electrolysis department

The Electrolysis department produces pure copper from raw copper anodes manufactured in the copper refining section.

The process consists of transfering copper ions (Cu++) from an anode to a cathode under a permanent electric field (obtained by direct current) and through an electrolyte (liquid containing 42 to 45 g/l of copper and 180 g/l of sulfuric acid). Electricity is the main source of energy of the process. Steam is also a significant source of energy since the electrolyte must be warmed up to obtain a temperature of 54° to 63° C in the electrolyte cell.

Direct current is generated from a high efficient thyristor battery manufactured by BBC. Electrical power source is 10 kV transformed to a lower voltage by a transformer.

The electrolysis plant consists of 12 blocks of 10 cells each. Each cell holds 27 anodes (raw material) and 28 cathodes (product).

Each cell has an average potential difference of 250 mV. Current is usually controlled at 7000 A.

Production per cell is given by the following formula:

P in kg/h/cell = 1.186 x I x eff

with I = Amperage in kA (usually 7)
eff = efficiency (usually .85)

That yields an average production of 170 kg of copper per cell and per day. The average direct current consumption is 1.75 kW/cell, i.e. 248 kWh per ton of copper.

The plant electricity to production ratio is usually in the range of 270 to 290 kWh/t.

Each anode weights 212 kg. At the begining of the electrolysis process, a cell will hold 212 x 27 = 5724 kg of anode copper.

A cycle of cathodes lasts 8 days. At the end of the cycle, each cathode will have a weight of 8 x 170 / 28 = 48.6 kg + weight of the starting cathode.

A batch of anodes will last for three cycles of cathodes. At the end of an anode cycle, 170 x 8 x 3 = 4080 kg of copper will have been transfered from anodes to cathodes. The remaining weight of anodes is (5724 - 4080)/27 = 61 kg, i.e. 29 % of the initial weight of anode. The remaining anodes are reprocessed in the refining plant.

1.2 Energy usage and historical data analysis

According to plant management, energy (including electricity, fuel, water and sewage) accounts for 7% of total cost of the company. Annual consumption is in the range of 900 to 1000 GJ/year for a total expected cost of 650 to 700 million Forints in 1991.

Total primary energy use of CSEPEL was 48,000 tons of oil equivalent in 1990. This primary energy use has been computed by RCG/Hagler,Bailly using the following conversion factors:

Energy	unit	kg of oil equivalent
electricity	kWh	0.426
natural gas	GJ	23.92
steam/hot water	GJ	28.15
compressed air	000Nm3	47.31

The following table shows the breakdown of primary energy use:

	tons of oil equivalent	percent of total energy
Total primary energy use	48,000	100
Process energy use	30,000	61
of which electricity	23,000	48
Non-process energy use	18,000	39
of which electricity	10,968	23

Findings are as follows:

o Electricity is the largest energy used in CSEPEL with 71% of the primary energy use.

o Non-process energy use accounts for a significant percentage (39%) of total energy use. This energy use constitutes a fixed cost to CSEPEL.

o Deeper investigation during the audit has shown that among the process energy use, a large part (estimated at 1/4 of the process energy use) is relatively independent of plant throughput (i.e. steam use, electricity use to run fans, pumps or cooling tower). In other words 25% of process energy use constitutes a fixed cost to CSEPEL.

o As a result, 55 % of total primary energy use is independent of production and constitutes a fixed cost to CSEPEL.

Based on the year 1990 energy consumption record and current energy price (March 1991), the energy bill including electricity, gas, steam, hot water and compressed air is evaluated at 554 million Forint broken down into the following categories:

	million FT/year	in % of total cost
Total energy cost	554	100
Demand charge (fixed cost)	100	18
of which electricity	92	17
Energy charge (variable cost)	454	82
process energy use	267	48
of which electricity	175	32
non process energy use	187	34
of which electricity	84	15

Findings are:

o Electricity accounts for 64% of the total energy bill

o By adding the annual demand charge (18%), the non-process energy use cost (34%) and 25% of the process energy use which is believed to be independent of production throughput (25% x 48% = 12%), we obtain 64% of the energy bill which can be considered as a fixed cost, regardless of the production rate.

o One of the key criteria for energy intensity in process operations is the level of scrap generated. This scrap has to be reprocessed again.

1.3 Previous actions to save energy

CSEPEL has a long history of undertaking energy conservation projects, and appears to be one of the most advanced companies in Hungary in this regard. For example:

- The energy department has an incentive to improve energy efficiency. This incentive is a performance bonus, based on specific energy consumption and total energy cost. They plan to revise the incentive to base it on individual products or processes within the next year.

- In the copper refining section, energy consumption was reduced from 10.61 GJ per ton of anode in 1988 to 9.76 GJ in 1989 and 8.98 GJ in 1990, an energy efficiency improvement of over 15%.

- In the copper electrolysis section, similar improvements have been made in electrical energy consumption, which was reduced from 414 kWh/ton in 1988 to 358 kWh in 1989 and 334 kWh in 1990, an energy efficiency improvement of nearly 20%.

- CSEPEL invested about $500,000 in a computer-based energy management system which was installed in 1988. This system monitors 640 loads and enables them to limit peak demand, achieving a payback of about 1 year.

- Mercury vapour lighting systems in the plant were converted to the more efficient high pressure sodium lamps over a period of three years. CSEPEL invested more than $100,000 in these projects.

- The company is now investing FT 170 million ($2.5 million) in an environmental project that also has energy savings, to be completed by the end of 1991. This project is for flue gas dust removal and for burning oil-contaminated copper. Heat released by the equipment will be used to generate steam for use in heating the pickling bath and for preheating makeup air for the workshop. This project, based on a Hungarian design, is financed by a combination of sources-environmental protection fund, bank loans, and CSEPEL itself.

An innovative energy conservation implementation methodology was pursued at CSEPEL:

- A comprehensive energy audit was carried out in 1984 by FERINOV (Ferum Innovation) assisted by Swedish consultants. FERINOV financed the cost of the audit as part of a 5-year shared savings contract. CSPEL paid for all investments arising from the recommendations of the audits, paying FERINOV for the know-how obtained through the audit.

- Resulting from the audit, shared savings projects of two parts were launched - (1) in non-production areas, such as lighting, activities were carried out and payments were made based on gross energy savings; (2) in production-related areas, the criterion was specific energy consumption in GJ/ton.

2. RECOMMENDATION FOR ENERGY EFFICIENCY IMPROVEMENT

Recommendations developed by RCG/Hagler, Bailly for energy efficiency improvement are sorted for convenience into three categories of action:

o Energy management improvement actions are the first category and have been emphasized by CSEPEL as a priority in a fast changing economic environment. Actions which fall in that category are coded by "A" preceeding the list number. CSEPEL should be able to implement these measures in the next six months, with assistance from the U.S.A.I.D. Emergency Energy Program.

o Low cost and short term implementable actions constitute the second category and are emphasized as action to which U.S.A.I.D. might be able to further contribute under its program. Actions of this category are indicated with a "B" preceeding a list number.

o High cost or long term actions constitute the third category and consist principally of technology improvement projects. Actions of this group are shown by a "C" followed by a list number.

2.1. Energy Management Improvement

2.1.1 Assessment of the existing energy management system

The energy department is equipped with an Energy Monitoring System (EMS) which centralizes energy consumption information from various meters throughout the plant and calculates energy demand on a 10 minute basis.

This EMS system consists of a micro VAX computer, from DIGITAL EQUIPMENT CORPORATION (DEC), and an Energy Management Software designed by a subsidiary of Imperial Chemical Industry (ICI).

The EMS system was originally installed to monitor electric power demand and electricity consumption and was licensed by the electric utility company to provide the reference data (kWh and kW, both for 10 kV and 400 V) for electricity billing. This invoicing method replaced a simple but inadequate and costly method based on a fixed charge which was the electricity consumption and maximum demand. This investment of the EMS system was repaid to CSEPEL in 1.5 year by the reduction of the electricity bill.

The current EMS system is configured to handle 640 signals which is enough to survey electricity, natural gas and steam consumption.

The EMS system is not designed to achieve an energy accounting function, i.e. allocate energy cost to production, monitor actual versus budgeted consumption and track performance trends.

This function is performed on a separate microcomputer requesting manual entry of data. The energy accounting system compares on a monthly basis both in physical and money units the initial cost budget, the expected cost corrected by the actual production rate and energy tariff, and the actual expenses. An energy expense progress report is issued by the energy department on a monthly basis which displays cumulated budget/expected/actual expenses starting from the first month of the year for each profit/cost center.

Both systems (EMS and energy accounting) are technically adequate and efficient.

The performance analysis is made at two levels: the profit/cost center and the energy department. The profit/cost center manager is responsible for the global expenses of the center, with little regard to the respective weight of each item of the expense report. In other words, an energy overexpense may be offset by a cost reduction for other items. No action will be taken, since the overall performance meets the target. The structure of the expense budget may be adjusted for the next year.

The energy department is responsible for the global energy expense performance of the plant (actual versus expected and/or budget): in case of overconsumption of energy, the energy department performance is considered as being insufficient and the monthly incentive on salaries is negative. The energy department is working to improve the evaluation performance method, since current mid-year performance evaluation is always negative while the end-of-the-year performance evaluation is always positive due to seasonal variations.

2.1.2 Management improvement recommendations

Action A.1: Improve the energy management and information system

Action A.2: Electric Power management task force

Action A.3: Compressed air management task force

Action A.4: Heat loss management task force

Action A.5: Create a combustion tune-up team

Action A.6: Manufacturing Resources Planning and Control System

2.1.3 Optimization recommendation

Action A.7: Insure production of copper anode with the existing reduction furnace

Action A.8: Optimize building heating

2.2. Low Cost and Short Term Energy Efficiency Improvement Actions

Action B.1: Control electrolyte heating temperature

Action B.2: Adapt combustion air preheater now installed on the oxidizing furnace for use with the reduction furnace (copper refining).

Action B.3: Revise casting die design to improve quality control

2.3. Investment or Long Range Energy Efficiency Improvement Actions

Action C.1: Heat recovery on refining furnaces

Action C.2: Preheating pickling fluid by submerged gas fired burners in replacement of steam.

3. PRESENTATION OF PROJECT FORMS

Each item discussed above is presented in a stand-alone project form which provides all basic information to qualify the project. The data is provided at the "inventory" level (first order of magnitude approximation), and includes the following:

- Description and rationale
- Calculation of savings (energy and others)
- Implementation cost
- Financial analysis limited to the pretax pay-back period
- Planning
- Technical risk and reference
- Back-up data and calculations

ACTION A.1

1. PROCESS AREA

Energy management

2. STATEMENT OF RECOMMENDATION

Improve the energy management and information system:

- o Adapt the energy consumption monitoring system to include energy efficiency monitoring
- o Expand the access to the energy data base to production departments
- o Treat energy losses through the distribution system as a separate energy user
- o Expand the energy management and information system to other utilities

3. DESCRIPTION/RATIONALE

This action is geared to the enhancement of the existing energy management system (EMS) in use at CSEPEL:

3.1 Adapt the Energy Consumption Monitoring to include energy efficiency monitoring

Basically the EMS system provides all information on the consumption of energy "anywhere" and "at any time". Currently, it does not say automatically if the use of energy is efficient, nor monitor the trend of productivity for energy use. This function is essential in the search of efficiency or productivity improvement.

The first step to enhance the EMS system towards an energy efficiency monitoring system would consist of entering production data and have the system display the trend of energy to production ratios.

Since a large part of energy use in the plant is related to space heating, it is recommended to monitor the degree-days (summation of average daily temperatures minus target temperature) using an ambient temperature thermometer. The degree-day indicator could be calculated by integration of the ambient temperature. The ratio of energy for space heating to degree-days plays the same role as the

energy to production ratio: it provides a good indicator of the efficiency of space heating.

This would require some enhancement of the existing energy management software.

3.2 Expand the access to the energy data base to production departments

Currently, only the energy department has an access to the energy data base collected by the energy management system using the two existing terminals. Those terminals are used on a daily basis by energy department engineers for data analysis and recommendations for action. Beyond energy accounting, this feature has proven very useful for troubleshooting and energy efficiency improvement. Currently the number of available terminals is a bottleneck in the capacity of analysis and decision-making. In addition, there is a demand from process department engineers to have access to the energy database.

It is recommended to install additional terminals, at least in each process department (there are three process departments in the plant).

3.2 Treat energy losses through the distribution system as a separate energy user

It was found that one objection to the existing energy management system is that heat losses in the distribution system are allocated to the end-user. Therefore, the end-user is less motivated to improve efficiency: any effort is partially offset by constant heat losses through the distribution system. For example, the electrolysis department manager does not feel responsible for the steam consumption which is attributed to the department, until a steam meter is installed at the incoming line of the electrolysis building.

If steam meters were to be installed at all steam user points, the summation of steam consumption at the user points would be less than the quantity of steam purchased from the power company. This difference (both in ton and gigajoule) must be attributed to the distribution system losses. It sounds logical that the energy department be charged of energy distribution losses and, consequently, receives allocated funds to maintain and improve the distribution system.

This applies to heat losses on the steam and hot water system, water and compressed air leaks in distribution pipes and electric power losses through transformers and wires.

3.3 Expand the energy management and information system to other utilities

There is a need and an ongoing program to expand the metering system to utilities other than electricity, according to the following schedule:

- Natural gas and steam consumption.....1991
- Hot water consumption.....1992
- Compressed air consumption.....1993

4. BENEFITS

4.1 Energy savings

A high motivation for efficiency improvement (energy and other operating costs) was found at CSEPEL. This motivation is kept high partly because of the design of the management system and an incentive program, resulting in a real pressure for efficiency improvement.

In these conditions, initiatives for efficiency improvement is a function of the quantity and quality of information available. Therefore, any improvement in the information system will be followed by immediate improvements.

This hypothesis was confirmed in the past. For example, the energy intensity at the copper refining plant has dropped from 11.5 GJ/t in 1988 (date of the start-up of the EMS) down to 9.5 GJ/t in 1991.

It is expected a 2% energy savings from this investment, i.e. 8 million Forint per year.

4.2 Other benefits

Because the EMS system provides information on a minute basis, it has a great capability to assist plant engineers for troubleshooting. It is expected that an additional annual savings of 4 million Forint, not related to energy, will be achieved.

5. IMPLEMENTATION COST

Equipment	cost
o Ambient temperature	$500
o Terminals for the energy information system . Monitor . Printer	$25,000

Total investment is 1,800,000 Forint.

6. PAY-BACK

The gross pay-back period is less than two months.
Actually, this investment will be paid with the results of the first decision made in a process department in view of the information provided by the terminals.

It is considered that a real pay-back of 6 months is conservative.

7. SCHEDULE

This action has been ranked as top priority by the energy manager after analysis of all recommendations of the preliminary energy audit report. The procurement of 3 terminals and related tasks are scheduled as follows:

Task 1 - completion date: May 2, 1991

EGI addresses to CSEPEL a specification of computer equipment

Task 2 - completion date: May 8, 1991

CSEPEL approves specification

Task 3 - completion date: May 24, 1991

HBI gets quotations from US manufacturers
EGI addresses to CSEPEL an evaluation of collected quotations

Task 4 - completion date: May 31, 1991

CSEPEL reviews offers, finalizes specification and makes recommendation for selection of supplier.

Task 5 - completion date: June 7, 1991

USAID gives clearance for equipment procurement based on HBI financial and economic study and evaluation of quotation.

Task 6 - Completion date: June 10, 1991

HBI sends purchase orders for equipment.

Task 6 - completion date: July 15, 1991

Shipment of equipment arrives in Hungary.
CSEPEL procures accessories and installation plans for computer equipment.

Task 7 - completion date: July 30, 1991

Delivery and installation of computer equipment at CSEPEL

Task 8 - completion date: August 30, 1991

Training period for the use of terminals

Task 9 - completion date: September 1, 1991

Production departments are fully operational to use terminals

8. TECHNICAL RISK AND REFERENCE

Technical risk is minimum since the specified equipment is already in operation with the full satisfaction of CSEPEL.

9. SPECIFICATION OF EQUIPMENT

9.1 ATMOSPHERIC TEMPERATURE SENSOR

This consists of a thermocouple located in a protective box to be fixed on the external wall of the building containing the MicroVax central processing unit. The thermocouple wire will be connected on an entry port of the EMS system, for direct voltage measurement and calculation of actual temperature

9.2 TERMINALS FOR THE ENERGY INFORMATION SYSTEM

For standardization reasons it is recommended that the equipment be manufactured by Digital Equipment Corp. (DEC), unless fully compatible equipment is found on the U.S. market.

9.2.1 EXISTING CENTRAL UNIT (FOR INFORMATION)

CSEPEL is equipped with a MicroVax 11 computer system. This equipment currently supports two terminals and is configured to support the three additional terminals considered in that project. For information, characteristics of the central unit are presented below:

Central Processing Unit characteristics

5 Mbyte RAM, RD54 159 MByte disk drive, TK50 95 Mbyte tape drive, DHQ11-8 Asynch serials lines, BA123 enclosure.

Operating system software and documentation

VMS 8 user license (ver 4.7), VMS Media & Documentation kit (ver 4.7), Diagnostic and documentation.

Accessories

4 Mbytes RAM, power cord

9.2.2 TERMINALS

Number of items: 3

Reference DEC model: VT 340

Existing host system: MicroVax 11, VMS 4.7 (see above)

Specification for one unit

Monitor:	graphics (800 x 480 pixels) displays 24 lines of text 14" 16 colors
Keyboard:	includes 15 user-defined keys
Memory:	up to 144 lines of text
Set-up functions:	accessible from keyboard
Power requirement:	220 V, 50 Hz

Accessories and spare parts

3 Terminal cleaning kits
1 clear keyboard overlays (box of 10)
3 set of programmer manual, user manual and maintenance manual.

9.2.3 PRINTERS

Number of items: 3

Reference DEC model: LA 75

Specification for one unit

Print method:	Incremental with bidirectional lookahead
Print speed:	from 32 to 250 characters/second
Graphic mode:	DEC and IBM mode
Characters:	ASCII and Hungarian characters sets
Form dimensions:	single sheets: 3 to 9 inches wide
Paper feed method:	Friction and tractor feed
Ribbon cartridge:	operator installable
Power requirement:	220 V, 50 Hz
Power consumption:	less than 180 W
Weight and dimension:	compact size suitable for desk-top location
Data interface:	serial RS423 and RS232-C EIA Standard 2 Kbyte input buffer

Accessories and spare parts

paper:	20 boxes of lineprinter paper (2000 sheets)
ribbons:	6 boxes of 6 printer ribbons

ACTION A.2

1. PROCESS AREA

Energy management

2. STATEMENT OF RECOMMENDATION

Electric Power management task force

3. DESCRIPTION/RATIONALE

During the course of the Preliminary Energy Audit the following facts were found:

o Amperage on the three phases feeding some induction furnaces were found imbalanced (Leich, Russ I). It was found that some inductors are damaged and are not operated at the same load as inductors on the other phases.

o Power factor on some induction furnaces were found capacitive (e.g. Russ II). It was found that capacitor correction on these furnaces is not operated on a control basis but is constant. Since the capacitors connected are sized to the full load of furnace, the power factor becomes capacitive at partial load.

o Short circuit to the ground was found on one furnace (Leich) precluding any safe measurement using our portable equipment and jamming the existing meter on that furnace, making useless the information provided by that meter.

o Plant staff in the continuous casting department were complaining about power limitation on some induction furnaces (e.g. AEG II and Russ II) because of cable overheating problems or problems at the transformers level.

o No specific protection against harmonic current (filters of what so ever) were found in the electric circuit, although presence of harmonic current is checked regularly by the electric utility.

o Little concern is given to the electrical power factor since there is no measurement of reactive power and no charge by the electric utility.

An electrical load essentially composed of inductance, capacitors and thyristor batteries is potentially subject to harmonic current. The risk is even higher when capacitor load control is out of order and connected load on specific phases are damaged.

Another event which occurred during the audit suggests that there might be some additional problems related to the protection systems of the incoming load. A power shutdown occurred on 3/19/91 at around 5 p.m. According to the plant staff, this is a very rare event. The power shutdown occurred very smoothly with a continuous decrease of voltage over a period of 5 seconds before total shutdown. The audit team would have expected that the protections would have disrupted the load as soon as a variation of voltage or frequency would have been detected.

It is recommended that Csepel institute a power management task force to investigate potential safety problems on electric circuits and determine adequate protections. This task force should be equipped with adequate measurement equipment.

4. BENEFITS

4.1 Energy savings

Energy savings expected from this project are estimated as 1% of electrical consumption (800,000 kWh/yr, Ft 5 million, $70,000).

4.2 Other benefits

The major contribution of this project is production increase both in quantity and quality through a better reliability of the electrical system.

5. IMPLEMENTATION COST

For the project, procurement of a power demand analyzer with harmonic analysis is planned, at a cost of $15,000.

6. PAY-BACK

The estimated payback is:

$15,000/$70,000/yr - 3 months

7. SPECIFICATION

Dranetz 8000 power demand analyzer or equivalent:

Measured parameters:
- Voltage: 3 channels, 60-600 VAC± 0/1%
- Current: 4 channels, 50-3000 amps AC, ±0.1%
  3x(50-1000) amp CTs and 3x(100-3000 amp CTs)
- Frequency: 30-100 Hz, ±0.2%
- Digital: 4 channels, 12-48 VDC

Computed parameters:
- Demand: kW, kVA, kVAR, ±0.2%
- Energy: kWh, kVAh, kVARh, ±0.2%
- Power factor (cos phi): ±2%

Display
- LCD, graphical alphanumeric

Printer
- graphics, thermal

Serial port:
- RS-232 D

Modem:
- 2400 baud, Hayes compatible

Memory:
- store up to 30 days at 15-minute intervals

Harmonics:
- measure up to 50th harmonic at 50 Hz

Reports:
- custom programmed by user

Uninterruptible power supply:
- 2 hours back-up

Power:
- 50 Hz, 220 VAC

Environment:
- 5C-45C, 0-90% humidity

Rugged portable case

ACTION A.3

1. PROCESS AREA

Energy management

2. STATEMENT OF RECOMMENDATION

Institute a compressed air management task force

3. DESCRIPTION/RATIONALE

Based on surveys conducted by the energy department, it was found that 40% of the compressed air demand throughout the plant results from air leaks.

It is recommended to institute a compressed air management task force to reduce the amount of air leakage. This management task force should be equipped with adequate instruments to detect air leaks. An ultrasonic tester is the most useful instrument for that purpose.

Additional metering of compressed air will be of great help to this task force. The energy department has scheduled that the metering of compressed air consumption should be completed by the year 1993.

4. BENEFITS

4.1 Energy savings

In 1990, compressed air accounted for a total consumption of 39.3 million m3 equivalent to 3.9 MWh. The annual average power demand is 450 kW. The annual cost for compressed air is 14 million Ft.

It is expected that the compressed air task force will reduce air leaks from 40% down to a reasonable 10%. This is equivalent to reduction of power demand of 135 kW.

Annual savings is expected to be 4.2 million Forint.

4.2 Other benefits

5. IMPLEMENTATION COST

ultrasonic testers	2 x $1000	=	$2000

Total equipment cost is 140,000 Forint for the instrument.
The manpower cost is 300,000 Forint x 2 = 600,000 Ft/year

Repair works budget should be 2,000,000 Ft for the first year and 1,000,000 Ft for the next years.

Total cost of the project is around 4,000,000 Ft

6. PAY-BACK

The pay-back period is less than one year.

7. SCHEDULE

This action has been approved by the plant's energy manager during the 4/30/91 meeting for immediate implementation:

Task 1 - completion date: April 30, 1991

HBI prepares and addresses specification of a portable ultrasonic tester to CSEPEL.

Task 2 - completion date: May 7, 1991

HBI gets quotations from US manufacturers

Task 3 - Completion date: May 14, 1991

CSEPEL reviews offers, finalizes specification and makes recommendation for selection of supplier.

Task 4 - Completion date: May 20, 1991

USAID gives clearance for equipment procurement based on HBI financial and economic study and evaluation of quotation.

Task 5 - Completion date: May 21, 1991

HBI sends purchase orders for equipment.

Task 6 - completion date: June 15, 1991

Shipment of equipment arrives in Hungary.

CSEPEL creates a compressed air leak team and defines a 3 month program of activity for the team.

Task 7 - completion date: September 15, 1991

Findings and recommendations of the compressed air team are submitted to the energy manager.

Final report will include lay-out of the compressed air system and indication of leaks detected.

Schedule for a crash program for compressed air leak repairs is established.

Task 8 - completion date: November 15, 1991

Completion of the compressed air leak crash program.

Task 9 - completion date: November 30, 1991

CSEPEL assigns target for compressed air consumption and monitors achievement as part of the energy management system.

8. TECHNICAL RISK AND REFERENCE

9. SPECIFICATION OF EQUIPMENT

ULTRASONIC TESTER

The ultrasonic tester will be used to detect at distance (up to 5 meters) the presence of air leaks along the compressed air pipes and user equipment. To avoid any jamming with surrounding noise, the probe must be capable of detecting ultrasonic emission in a closed angle around the direction pointed out by the operator. A head set is necessary to permit the operator to focus its attention in pointing the right direction instead of reading the displacement of a needle.

- **Physical description:**

case	insure protection against choc and dust
probe	directional probe

- **Electrical:**

battery	6V, rechargeable, quick recharge
AC	220V 50Hz

- **Display:**

- **Measured Parameter:**

Sound level in db
Ultrasonic range

- **Head set:**

ACTION A.4

1. PROCESS AREA

Energv Department

2. STATEMENT OF RECOMMENDATION

Institute a heat loss management task force

3. DESCRIPTION/RATIONALE

During the audit, it was found that the temperature of steam at the user point (e.g. electrolyte heating room) is only 165°C while the temperature of steam delivered by the power plant is over 230 °C. That means that steam has lost all its superheat temperature in delivery pipes which accounts for a heat loss of 6% of the enthalpy of steam. Some condensation of steam in the pipes us expected. The overall heat loss through bad insulation is evaluated at 10% of the original enthalpy of steam.

For hot water, heat losses through delivery piping system are estimated at 14 % by CSEPEL, and are already identified as a separate item in CSEPEL's energy management system.

4. BENEFITS

4.1 Energy savings

Total heat losses through the hot water and steam system costs about 14 million Forint per year to CSEPEL.

It is proposed that the heat loss task force reduce losses by 7 million Forint a year.

4.2 Other benefits

5. IMPLEMENTATION COST

List of equipment	number	unit cost (Ft)
Infrared camera		
Infrared thermometer		

6. PAY-BACK

For an investment of Ft 1.2 million, the energy savings of Ft 7 million will achieve a payback in 2 months.

7. SCHEDULE

This action has been approved by the plant's energy manager during the 4/30/91 meeting for immediate implementation:

Task 1 - completion date: April 30, 1991

HBI prepares and addresses specification of a portable infrared camera and portable infrared thermometer to CSEPEL.

Task 2 - completion date: May 7, 1991

HBI gets quotations from US manufacturers

Task 3 - Completion date: May 14, 1991

CSEPEL reviews offers, finalizes specification and makes recommendation for selection of supplier.

Task 4 - Completion date: May 20, 1991

USAID gives clearance for equipment procurement based on HBI financial and economic study and evaluation of quotation.

Task 5 - Completion date: May 21, 1991

HBI sends purchase orders for equipment.

Task 6 - completion date: June 15, 1991

Shipment of equipment arrives in Hungary.

CSEPEL creates a heat loss team and defines a 3 month program of activity for the team.

Task 7 - completion date: September 15, 1991

Findings and recommendations of the heat loss team are submitted to the energy manager.

Final report will include lay-out of the steam and hot water system and indication of losses detected.

Schedule for a crash program for insulation repairs is established.

Task 8 - completion date: November 15, 1991

Completion of the insulation retrofit crash program.

Task 9 - completion date: November 30, 1991

CSEPEL assigns target for steam and hot water heat loss and monitors achievement as part of the energy management system.

8. TECHNICAL RISK AND REFERENCE

9. BACK-UP DATA AND CALCULATION

1990 Annual consumption of steam and hot water (including losses)

	GJ	000Ft
Process steam	105992	51406
Non process steam	78403	38026
Hot water	101620	42477
	---	---
	285015	131909

10. SPECIFICATION OF THE EQUIPMENT

INFRARED PORTABLE CAMERA

The infrared camera will be used to detect hot spots along steam and hot water pipes running on overhead pipe racks. It will be provided with a wide angle lens to get a fairly large picture (roughly 10 meters of pipe hanging at 3 m above the ground level). It is expected to detect temperature differences of 5°C. The camera will have an eye viewer. Snap shot is not requested.

A regular instantaneous camera (polaroid or equivalent) may prove helpful to show the portion of pipe to be repaired in the report.

The camera will be used along with an infrared thermometer, allowing a fairly accurate temperature measurement of spotted point.

o **Physical description:**	
case	insure protection against choc and dust
o **Electrical:**	
battery	6V, rechargeable, quick recharge
AC	220V 50Hz
o **Display:**	eye viewer

ACTION A.5

1. PROCESS AREA

Energy Department

2. STATEMENT OF RECOMMENDATION

Create a combustion tune-up team

3. DESCRIPTION/RATIONALE

Csepel has several metal treating fuel fired furnace operations which were examined for their heat recovery potential.

PROCESS AREA	ANNUAL FUEL CONSUMPTION (GJ)	% OF TOTAL
Copper melting	65,000	70
Aluminum recovery	15,000	16
Tube & rod drawing	6,600	7
Hot milling	3,300	3.6
Heat treatment	2,700	1.3
	92,600	100.0

These metal treatment or heating furnaces have usually high stack gas temperature (between 500°C and 900°C). Therefore the control of excess air is critical to maximize their efficiency.

4. BENEFITS

4.1 Energy savings

The combustion tune-up team is expected to reduce the annual gas consumption by 2%, i.e. 2,000 GJ/year, worth 530,000 Ft/year

4.2 Other benefits

5. IMPLEMENTATION COST

List of equipment	number	unit cost (Ft)
portable gas analyzer	$3000	

Total cost is 210,000 Forint.

6. PAY-BACK

The pay-back period is around 6 months.

7. SCHEDULE

This action has been approved by the plant's energy manager during the 4/30/91 meeting for immediate implementation.

Task 1 - completion date: April 30, 1991

HBI prepares and addresses specification of a portable combustion gas analyzer to CSEPEL.

Task 2 - completion date: May 7, 1991

HBI gets quotations from US manufacturers

Task 3 - Completion date: May 14, 1991

CSEPEL reviews offers, finalizes specification and makes recommendation for selection of supplier.

Task 4 - Completion date: May 20, 1991

USAID gives clearance for equipment procurement based on HBI financial and economic study and evaluation of quotation.

Task 5 - Completion date: May 21, 1991

HBI sends purchase orders for equipment.

Task 6 - completion date: June 15, 1991

Shipment of equipment arrives in Hungary.

CSEPEL completes an operating procedure for the use of the portable gas analyzer including where should it be stored, who would use it, frequency of use, etc...

Task 7 - completion date: July 1, 1991

Tune-up of combustion starts based on combustion gas analyzer measurements.

Task 8 - completion date: September 1, 1991

CSEPEL assigns target for furnaces energy intensity and excess air and monitors achievement as part of the energy management system.

8. TECHNICAL RISK AND REFERENCE

9. BACK-UP DATA AND CALCULATION

10. SPECIFICATION OF EQUIPMENT

ELECTROCHEMICAL PORTABLE GAS ANALYZER

o **Physical description:**	
case	insure protection against choc and dust
probe	high temperature probe
o **Electrical:**	
battery	6V, rechargeable, quick recharge
AC	220V 50Hz
o **Display:**	LCD with backlight
o **Measured Parameters**	
Ambiant temperature	0-150°C
Stack temperature	0-1100°C
Oxygen sensor	0-25%, electrochemical cell, life > 1 year
Nitrogen oxide	0-2000ppm, electrochemical cell, life > 2 years
Carbon monoxide	0-2000ppm, electrochemical cell, life > 2 years
Combustion gases	0-2.5%, semiconductor sensor, life > 5 years
Draft	piezoresistive sensor
o **Computed parameters:**	
Excess air	
Combustion efficiency	
Carbon dioxyde	
Emissions (CO, NOx)	
o **Printer:**	built-in thermal printer with form feed and line feed buttons

- **Miscellaneous:**

Fuels	3 or more fuel in memory + custom fuel
Messages	diagnostic and help messages in english
Calibration	Optional autozero on start-up

- **Parts**

Oxygen cell
CO cell
paper for printer

ACTION A.6

1. PROCESS AREA

Rolling Mill department

2. STATEMENT OF RECOMMENDATION

Install a Manufacturing Resource Planning and Control System

3. DESCRIPTION/RATIONALE

Existing conditions

The CSEPEL cold rolling mill plans its operations based on orders, and also produces for inventory. The orders are converted into a monthly program for the casting shop to produce coils. These coils are then rolled, shaved and cut in the rolling mill. The system is done manually, based on the long experience of Mr. RAB Andras, who plans the production process. The system currently requires an average of 1.3 ton of coil for 1.0 ton of product, against a target of 1.2. This difference represents an energy loss in the CESPEL copper and brass rolled strip production plant (thermal and electrical energy) of 7%, with a corresponding loss of productivity. This scrap is recycled, so raw material is conserved, but energy is required as the material must be remelted, recast and rerolled.

Findings

RCG/Hagler,Bailly observes that the production planning system at CSEPEL is traditional and does not reflect the systems in place in western plants which compete with CSEPEL on world markets. For job shop operations such as the casting plant and rolling mill, computer-based planning tols (Manufacturing Resource Planning - MRP) are available which can optimize the selection of casting widths and thicknesses to achieve a higher ratio of productive output to cast material, thereby saving energy and increasing productivity. CSEPEL management sees the need to institute an MRP procedure, since Mr. Rab plans to retire in just a few years.

Recommendations

RCG/Hagler,Bailly recommends that an MRP system be procured for CSEPEL, under the USAID Emergency Energy Program. Installation and programming of this system should be carried out in Hungary, by local firms, to ensure language compatibility and software support.

4. BENEFITS

4.1 Energy savings

The estimated energy savings from the system is 3% in the first year of operation and 5% in the second and subsequent years, compared to the energy used in the melting, casting and rolling operations per ton of product. This amounts to Ft 30 million per year ($400,000).

4.2 Other benefits

5. IMPLEMENTATION COST

MRP system and basic software: $100,000
Hungarian programming and adaptation: $100,000

6. PAY-BACK

The payback is estimated at 6 months, based on an investment of $200,000 and a savings of $400,000.

ACTION A.7

1. PROCESS AREA

Copper melting

2. STATEMENT OF RECOMMENDATION

Reduce gas consumption for copper melting by using only the reducing furnace abandoning the current three furnace systems.

3. DESCRIPTION/RATIONALE

Electrolytic copper is one of the principal intermediate products produced at Csepel. As originally conceived, all copper used for anode production for the electrolysis process is first melted and purified in a series of three furnaces, each designed to perform a single function. The first furnace is a vertical shaft design which melts mixtures of scrap and blister copper in proportions based on their availability. The copper feed stock is brought to the top of the furnace by an elevator and the raw copper works down the shaft against combustion gas produced at the base of the furnace equipped with three fuel gas burners. When the melt reaches the bottom, it passes to the oxidizing furnace where impurities are removed by oxidation using air lances. Slag formed during the lancing is tapped and the melted copper is channeled to a reduction furnace where carbon is added (whole trees are charred in the melt to provide the carbon used for reduction). The purified copper is heated some 50°C above its melting point and the reduction furnace is tilted and the melt poured into anode molds on a turntable. The anodes are quenched and transported to the electrolysis area.

In concept, the system appears to be continuous, but it is really semi-continuous. The shaft furnace must be fed intermittently, allowing the impure copper feed to soften and move down the shaft furnace before there is room for more impure copper to be added. The oxidation and reduction furnaces are designed to hold 30 tons of hot metal. In order to provide 30 tons of melted raw copper to the oxidizing furnace, the shaft furnace must be filled and emptied several times. During this period the oxidizing and reducing furnaces must be kept hot even if empty or partially filled.

There are times when there is insufficient raw copper, blister or scrap, to start the sequence of three furnaces. When this occurs the entire process of melting, oxidizing and reducing is performed in only the last (reducing) furnace. The gas burner for the reducing furnace is fired through a front door which swings open to

allow a fork lift to move raw copper into the furnace. Only a limited amount of copper can be delivered to the furnace each time the door is opened. Therefore, the process must be repeated about 4 to 5 times, over a 90 minute period, to deliver sufficient copper to produce a 30 ton charge forecasting. When sufficient copper has been added to the reducing furnace the charge is lanced with oxygen through pipes at the bottom of the furnace and then reduced. Finally the charge is heated above its melting point and cast.

The reduction furnace was not designed for slagging. A tapping hole is available but is below the level of the melted copper in the furnace when it is full. Slag can only be removed from this furnace when the hot metal has been partially poured to the anode molds, and this is done by reaching in with rakes to pull the slag from the furnace, after which pouring is resumed.

An examination of melting plant data for the year 1990 (see attached table) shows that about 80% of the annual production of 7,000 tons was performed in the 3 furnace system with a weighted average specific energy consumption of 9.9 GJ/t of copper. The reduction furnace was used to produce the balance of the melted copper but with a smaller weighted average specific energy expenditure of 7.2 GJ/t.

Based on reducing furnace data, it takes approximately 23 hours to (intermittently) charge, then oxidize and reduce, pour and slag, to produce 30 tons of anodes. Note that 30 tons of anode is the daily average consumption of the electrolysis department at full capacity. If the furnace is operated continuously, three shifts including weekends and holidays, 7,000 tons of anodes could be produced in about 5,400 hours (7.5 months). This is sufficient time to include the usual two months of down-time for maintenance.

4. BENEFITS

4.1 Energy savings

Based on the specific energy calculations described above, it appears that if all the anodes produced in 1990 had used copper that had been melted only in the reduction furnace, about 559,000 cu m of fuel gas, or 27%, of the annual fuel used for melting could have been saved. This fuel is valued at over 5 million Ft. Future similar savings could be anticipated if this procedure is adopted.

4.2 Other savings

5. IMPLEMENTATION COST

A similar recommendation appears to have been considered at Csepel but not acted upon. The plan would have moved the reducing furnace some distance from its present location in order to allow a new slag hole to be added to the furnace. Alternatively, the furnace would remain in its present location and the channel connecting the oxidation and reducing furnaces would have been removed. This would have provided space for adding a new slagging hole. Estimated costs for these alternatives is about 2 million Ft.

It is suggested that neither alternative be implemented but that the melting operation be transferred to the reducing furnace with slagging continued as at present despite its inconvenience. The furnace, in its present location, and despite the difficulty of slagging, appears fully capable of producing 7,000 tons of copper annually without incurring the cost of relocating or alternative modification.

6. PAYBACK

This recommendation is a no-cost modification coupled with a rather impressive savings of annual fuel costs.

7. PLANNING

It should be possible to produce a maximum of slightly more than 9,000 tons of anodes with only the reduction furnace, if a 10 month continuous schedule is planned. Additional production, if required, could be picked up in the present oxidation furnace. This could be done by modifying the oxidation furnace to a front loading system similar to the reducing furnace. The oxidation furnace could be charged, as the reducing furnace is now loaded, the charge melted and oxidized. The oxidized material could then be channeled to the reduction furnace for reducing and casting. A coordinated production schedule using both the reducing and modified oxidation furnace could produce well over 10,000 tons of copper for casting annually.

8. TECHNICAL RISK

o If the reducing furnace suffers a major breakdown, production of anodes stops. However, the same risk now exists if any of the furnaces break down.

o If production demands increase beyond about 9,000 tons/year, the reducing furnace will not be able to provide sufficient material. This is the reason for suggesting that the oxidizing furnace be kept in place and modified for tandem operation with the reducing furnace.

ACTION A.8

1. PROCESS AREA:

Energy demand management

2. STATEMENT OF RECOMMENDATION:

Building heating optimization consisting of:

o discontinuing heating in areas where building heating is not necessary.

o Optimization of the incoming temperature of hot water (from the power plant) in function of the ambiant temperature

3. DESCRIPTION/RATIONALE:

During the plant walkthrough the followings facts were discovered by the audit team:

o The electrolyte storage and processing room at the electrolysis plant was found heated by steam coils fixed on the wall while a considerable amount of heat is radiated by the electrolyte storage tank and the presence of staff in the room is strictly limited because of potential health hazard resulting from the exposition to sulfuric acid vapors. The amount of condensate flowing from the heating coil to the sewer was estimated at 150 kg/h.

o Some management buildings were found heated with steam coils with no control resulting in a general overheating (e.g. the electrolysis plant management building).

o The restaurant, provided with large windows, was found overheated while the sunshine was glaring through the windows.

o The energy use for building heating was found out of proportion with the variations of degree-days for the period.

These facts lead to the conclusion that the building heating system of CSEPEL is inadequate, not controlled and wasteful.

The following actions are recommended:

o dismantle building heating steam coils in workshops provided with heat dissipating machinery and anywhere employees do not have to stay seated, motionless or at rest for more than 10 minutes.

o In office buildings heated with steam, it is recommended to take the three following steps successively on the short, medium and long term:

(1) replace as soon as possible disc traps by thermostatic traps designed to flush condensate well undercooled below the boiling temperature of water;

(2) For the next heating season, install at the entrance of each steam heated building pressure reducing valves to limit the pressure of steam and, therefore, reduce its condensing temperature;

(3) make plans to replace the steam heating system by a warm water heating system, should the warm water be generated using steam.

o For spaces heated with warm water purchased from the power plant, it is recommended to take the following steps by order of priority:

(1) negotiate with the district heating company a modulation of the hot water temperature in function of weather condition (ambiant temperature, sunshine, wind speed). The power plant is already modulating the hot water temperature from 90°C (ambiant temperature 12°C, return water temperature 40°C), to 120°C (ambiant temperature -15°C, return water temperature 60°C). In any case the temperature of hot water should be reduced at night.

(2) renegotiate with the district heating company (power plant) the pricing of hot water to obtain a time of the day pricing. The actual cost of warm water production to the power plant is much lower during peak hours than during night hours because of the modulation of electricity pricing. In any case, for an identical daily average price of heat, CSEPEL should accept a tariff with higher price during night hours and lower price during day and peak hours. Because a reduced rate of occupancy of building at night and in the scope of an improved building heating energy management, a time of the day tariff would be conducive of a significant reduction of the cost of hot water to CSEPEL.

(3) install thermostatic valves on each radiator (regular valves for a two-pipe system, three-way valves for a one-pipe system).

ACTION B.1

1. PROCESS AREA

Electrolysis Plant

2. STATEMENT OF RECOMMENDATION

Control electrolyte heating temperature

3. DESCRIPTION/RATIONALE

The electrolyte for the copper electrolysis is a highly acid solution consisting of sulfuric acid and copper sulfate, kept at the temperature of 50/60°C using open end steam coil located at the bottom of the tank. Heat load is high enough to condense the totality of steam flow. Condensate is collected in a condensate recovery tank and then sewed.

Important heat losses occur through the open air surface of the tank.

It is recommended:

o to control the temperature of electrolyte inside the tank at the temperature of 45°C, above the crystallization point of sulfate (35°C).

o to use the steam heated exchanger located at the exhaust of the circulating pumps to raise the temperature of electrolyte up to 60°C.

ACTION B.2

1. PROCESS AREA

Copper melting

2. STATEMENT OF RECOMMENDATION

Adapt combustion air preheater now installed on the oxidation furnace for use with the reduction furnace.

3. DESCRIPTION/RATIONALE

Combustion air for the reduction furnace is presently drawn directly from the furnace room to the furnace burner without preheating. This air can be preheated using the combustion air preheater installed on the unused oxidation furnace.

Combustion gas leaves the reduction furnace at about 1200°C and is mixed with exhaust combustion gases from the combined shaft and oxidation furnaces. The mixed exhausts are cooled with water and injected with pulverized limestone to absorb sulfur oxides. The particulates are removed with an electrostatic precipitator and exhausted through a tall stack.

A valve is located at the junction of the exhaust ducts from the shaft and oxidation furnaces with the reduction furnace exhaust duct. This valve is supposed to be shut when the shaft and oxidation furnaces are not operating. However, this valve cannot be tightly shut and the induced draft fan at the precipitator pulls air through the shaft and oxidation furnace exhaust lines which then mixes with hot exhaust from the reduction furnace cooling it rapidly. About 15 meters from the reduction furnace exhaust the temperature has dropped to almost 200°C due to this mixing.

Data available for reduction furnace operation during 1990 shows that average fuel use for this furnace is about 260 cu m/hour during copper melting. During a test of this furnace on March 15, 1991, fuel flow measured 280 cu m/h, in good agreement with the estimated value. Measured air flow during the test showed that the air-to-fuel ratio was about 10/1 (about 8% excess air).

4. BENEFITS

4.1 Energy savings

Preheating combustion air to 200°C would reduce the reduction furnace exhaust gas to about 1000°C. These are about the same conditions now found with the oxidizing furnace preheater. Potential savings in fuel for thereduction furnace are estimated at 0.84 GJ/h or about 19 GJ per 30 ton batch of copper melted. Assuming an annual production of 7,000 tons of anodes/year, the annual fuel savings would be about 4,500 GJ/year (about 130,000 cu m of natural gas at 34,000 kJ/cu m).

4.2 Other savings

This project will significantly lower the maintenance cost of the flue gas conditioning system. The current system suffers from severe corrosion problems related to different causes.

First, in the hot gas section, corrosion and fissuration problems derive from an overheating of the steel duct because of high temperature gas (over 500°C): this temperature is high enough to dissolve the carbon between the grains in steel, source of fragilization.

Secondly, the intermittent operation of the furnaces induces hot and cold cycles which provoke an early fatigue of steel under strength.

Finally, the presence of halogen or sulfur components in flue gas, harmless at high temperature, (over acid dew point) can be damageable to the pipe at low temperature (when the furnace is shut down).

This project will reduce the above mentioned risk by insuring a continuous operation of the existing reduction furnace.

5. IMPLEMENTATION COST

o The combustion air inlet is too close to the reducing furnace housing and must be relocated.

o Duct work and insulation for the combustion air inlet from preheater.

o Redirect flue gas exhaust from reducing furnace to oxidizing preheater.

Estimated total cost: 1.5 million Ft

6. PAYBACK

$$\text{Estimated payback} = \frac{1.5 \text{ million Ft}}{1.2 \text{ million Ft/y}} = 13 \text{ months}$$

ACTION B.3

1. PROCESS AREA

Copper metallurgy division

2. STATEMENT OF RECOMMENDATION

Revise casting die design to improve quality control

3. DESCRIPTION/RATIONALE

Existing conditions

CSEPEL casts copper and brass alloys in a continuous casting machine, in which solidification occurs as the material passes through graphite dies. Because of the thin cross-section of the cast material, the resulting heat flux profile across the water-cooled die is not uniform. At the edges, heat flux is substantially greater than along the main face of the material. The result is that the edges crack under the strain of the uneven cooling. This is especially frequent in the case of copper-phosphorous (CuP). CuP is a popular material, used for roof gutters, which makes up 8-10% of the production of CSEPEL's strip rolling mill. For CuP, an average of 2 tons of cast coil is required to provide 1 ton of output of CuP strip from the rolling mill (against the average for all CSEPEL products of 1.3), representing an increase in specific energy requirements for CuP of 53%.

Findings

RCG/Hagler,Bailly observes that alternative die materials, such as advanced ceramics, are now available that could improve the quality of CuP casting. Alternatively, a redesign of the cooling water ports in the die block could achieve a more uniform heat flux and prevent the differential strain.

Recommendation

RCG/Hagler,Bailly recommends that a search for alternative ceramic die materials be carried out and an initial set be procured for use by CSEPEL on an experimental basis. Further, RCG/Hagler,Bailly recommends that engineering experiments be carried out on the die cooling system, particularly the method of operation of the water flow valves, to correlate valve settings with quality. The engineering project should also analyze heat flux across the die, and develop a superior design for the cooling ports, if required.

4. BENEFITS

4.1 Energy savings

Once a solution to the problem is found, the estimated energy savings from the system is 50% per ton for CuP, as compared to the other rolled strip products at CSEPEL. With CuP accounting for about 8% of production, energy savings would represent 4% of the thermal and electrical energy used in the rolled strip process. This savings is estimated as Ft 10 million per year ($140,000).

4.2 Other benefits

Improved quality would reduce the use of raw materials and may increase the value of the products.

5. IMPLEMENTATION COST

Experimental dies: $10,000
Die cooling research project: $50,000

6. PAY-BACK

The payback is less than six months, based on an investment of $60,000 with a savings of $140,000 per year.

ACTION C.1

1. PROCESS AREA

Copper melting

2. STATEMENT OF RECOMMENDATION

Recover heat in combustion gas from reduction furnace to produce hot water or steam for process heat and building heating.

3. DESCRIPTION/RATIONALE

Csepel presently purchases all the steam and hot water used for air conditioning and process heating. Purchased steam is mostly used to produce hot water for process heating except in the tube and rod drawing area, where steam is directly injected into tanks to produce hot water to clean bar stock surfaces after pickling and prior to drawing.

Purchased hot water, at 80-100 °C, is used for building heating except for the annual period from May through September. During the balance of the year, purchased hot water is returned to the seller at about 50-55 °C and the cost of water is based upon the quantity purchased and the temperature difference. About 87,000 GJ/year of hot water is purchased with the maximum consumption occurring in January when about 20,000 GJ/month are purchased. On a daily basis, maximum hot water demand occurs about noon each day with some 48 GJ/hour (16 tons/hour) required.

Steam demand is rather uniform on a monthly basis with about 4.5 tons/hour consumed.

The recovery of heat from furnace combustion gases is a potential source of steam and hot water. Csepel has several metal treating fuel fired furnace operations which were examined for their heat recovery potential.

PROCESS AREA	ANNUAL FUEL CONSUMPTION (GJ)	% OF TOTAL
Copper melting	65,000	70
Aluminum recovery	15,000	16
Tube & rod drawing	6,600	7
Hot milling	3,300	3.6
Heat treatment	2,700	1.3
	92,600	100.0

The last three furnaces are too small to consider for heat recovery and particularly unsuitable because they do not operate continuously. The hot milling furnace currently recovers some heat by preheating combustion air. The aluminum recovery furnace, the second largest producer of combustion gas, has a washing system to remove particulates from the combustion gas which is in direct contact with scrap aluminum. It too, although a large user of fuel, operates intermittently.

The only suitable furnace to consider for heat recovery is in the copper melting area. As presently operated, this system is also unsuitable for heat recovery because of its intermittent operation. However, previous recommendations for the copper melting furnaces suggested a continuous operation of the reduction furnace to provide all the anodes required for electrolysis. If this recommendation is adopted, the opportunity for heat recovery from the reducing furnace would be feasible.

Three options were considered for heat recovery from the reduction furnace:

o Recover waste heat in the form of hot water and provide a closed-loop hot water circulating system for building heating. This option precludes the recovery of waste heat during the May-September period when no hot water for building heating is required. Also, hot water demand is variably dependent on the weather requiring the largest loads during the coldest months and reduced amounts as the weather moderates. Further, hot water demand is variable during each day; largest demand appears to occur about noon each day with significantly smaller amounts required at other hours.

o Use waste heat recovery to reheat the hot water now purchased to the temperature at which it was purchased. This alternative has the same problem as the first option; what to do with waste heat recovered during the period when no hot water is purchased during warm months and the variability with the weather.

o Use waste heat recovery to raise steam and distribute this steam to process areas now currently requiring steam. Because steam use in process areas is for the purpose of producing hot water, it might be possible to use condensate from these areas for building heating before returning to the heat recovery system.

This plan appears appropriate because steam demand is flat and waste heat recovery from the copper melting reducing furnace appears capable of producing about 20% of the plant steam requirements. The difficulty with this plan is that if the copper

melting furnace was to operate continuously, only 7.5 months per year would be required to meet current anode demand of 7,000 tons/year. This means a recovery boiler operating only partially during each year. It would be necessary, with this option, to find an alternate source of steam when the copper melting furnace is not operating, either firing the heat recovery boiler with natural gas during the period when furnace combustion gas is not available, or buying steam and hot water for this period.

The recovery of waste heat from copper melting furnace combustion gas would substantially increase the thermal efficiency of the furnace operation. Estimates of the thermal efficiency of the reducing furnace are shown in the table below based on measurements made during operation on 3/16/91 and is compared with an operation in which an air preheater and recovery boiler are used.

	GJ per 30 tons of copper melted	% of total
Fuel energy	203	
Copper (scrap or blister)		0
Combustion air		0
Total in:	203	
Output (as currently operated)		
Melted copper	22.3	11
Combustion gas	111.0	55
Losses (radiation, other)	69.7	34
Total out:	203.0	100
Output (with air preheater and recovery boiler)		
Melted copper	22.3	11
In steam produced	66.7	33
In preheated air	19.2	10
Combustion gas	25.1	12
Losses (radiation, other)	69.7	34
Total out:	203.0	100

The thermal efficiency of the reduction furnace as currently operated is only about 11%, defining efficiency as the percent of input heat that is used. For furnace operation with a preheater and additional heat recovery in steam, the thermal efficiency increases to about 54%.

4. BENEFITS

4.1 The available recovery of heat from the reducing furnace combustion gas is based on the use of an air preheater previously described in Action xi.x. Combustion gas inlet temperature to the recovery system would be about 1000°C.

o If only water is to be heated (the first two options) an exit combustion gas temperature was assumed to be 200°C to heat the water from 50°C to 100°C. In this way 16 tons/hour of hot water could be produced, exactly matching the peak daily demand. However, the melting plant would run 7.5 months per year and the hot water for building heat is not required for five months per year with no way of assuring heat would be recovered when needed for building heating. Thus the minimum benefit would be the saving of avoided cost for two months of warm water purchased per year or about 25,000 GJ of hot water and 10 million Ft annually.

o If waste combustion gas heat is used to raise steam (last option) a discharge gas temperature of 300°C was assumed and an estimated 1 ton/hour steam at 5 bars, 230°C could be produced. This steam could be distributed to selected process areas, such as heating the electrolyte used for electrolysis, or for heating wash water after pickling in the tube and rod area, or for building heating. The steam produced would save an estimated 17 million GJ of steam annually (7.5 months/year) and 8 million Ft annually. Additional savings could be realized if condensate from process heating could be used for building heating before being returned to the recovery boiler.

The boiler would require auxiliary fuel firing to provide steam during the 4.5 months when waste heat was not available. The cost of fuel alone to produce 1 ton/hour of steam for 4.5 months would be about 3 million Ft (assuming a boiler efficiency of 85%) plus the added investment cost for the dual purpose boiler measured against an avoided cost of steam worth somewhat less than 5 million Ft.

ACTION C.2

1. PROCESS AREA

Energy Department

2. STATEMENT OF RECOMMENDATION

Install small gas fired boilers in replacement of steam purchase

3. DESCRIPTION/RATIONALE

The cost of purchased steam by "useful" GJ is more than twice the cost of generated steam in a gas fired boiler:

The cost of purchased steam is 485 Ft/GJ, or more exactly 485 x 3 = 1455 Ft/ton since steam is metered by ton and then converted into GJ using a constant conversion factor of 3 GJ/ton. Although steam is purchased superheated at an enthalpy of 700 kcal/kg, we must consider that superheat heat is lost in the in-plant steam pipes which brings its enthalpy dwn to 658 kcal/kg. The useful heat of steam is the difference between steam enthalpy (658 kcal/kg) and condensate enthalpy (say 58 kcal/kg), i.e. 600 kcal/kg. Furthermore, we consider that 10% of that "useful" heat is lost through condensation in steam pipes. Therefore the actual useful heat of one ton of purchased steam is no more than 600 x 0.9 = 540 thermie, equivalent to 2.257 GJ. The actual cost of useful heat with purchased steam is 1455 Ft / 2.257 GJ = 645 Ft/GJ

The marginal cost of natural gas is 265 Ft/GJ. If steam was to be generated in a 85% efficiency boiler, the cost of useful heat would be 265 Ft/GJ / 0.85 = 312 Ft/GJ

Therefore, for any major steam use in the plant, it is recommended to substitute natural gas to purchased steam. Natural gas would be transformed into steam or hot water using a boiler.

For example, purchased steam consumption to preheat electrolyte in the electrolysis department is at maximum 1 t/h and 0.8 t/h on an annual average. This could be replaced by a 1 t/h capacity small package boiler and an annual average consumption of 2.1 GJ/h.

4. BENEFITS

4.1 Energy savings

The difference of cost between an average purchase of 0.8 t/h of steam and 2.1 GJ/h of gas is:

(0.8 x 3 x 485 - 2.1 x 265) x 24 x 365 = 5.3 million Forint

5. IMPLEMENTATION COST

List of equipment	number	unit cost (Ft)
package boiler	1	10,000.000

6. PAY-BACK

The pay-back period is around 2 years.

APPENDIX 1: List of data provided by the plant

- **Utility consumption monthly report:**

This report shows the progressive consumption of utility starting by the 1st of January as scheduled in the budget with the budgeted production, calculated from the budget using the actual production figures and actual (from the meters). Utility consumption is displayed both in physical units and in Forint. Differences are calculated between the actual consumption and the budgeted ones, and also between the actual consumption and expected from the budget corrected with actual throughput.

- **Monthly utility consumption data base**

A monthly utility consumption data base is maintained by the energy department. This data base gives the energy consumption in physical unit and Forint for each combination of the following parameter:

- year of operation
- month of operation
- utility code
- process unit code

The data is qualified by an data entry date.

- **Monthly production data base**

- **Purchase utility price list**

MEDIUM VOLTAGE ELECTRICITY				
voltage	kV	10.5		
		day	peak	night
hours	h/d	13	3	8
Contracted power	kW	7500	6200	7500
demand charge	Ft/kW/month	185	385	0
electricity cost	Ft/kWh	3.2	4.7	2.35
average price	Ft/kWh	3.10		
	Ft/month	3774500		

LOW VOLTAGE ELECTRICITY				
voltage	Volt	400		
		day	peak	night
hours	h/d	13	3	8
Contracted power	kW	7500	5700	7500
demand charge	Ft/kW/month	205	415	0
electricity cost	Ft/kWh	3.7	3.7	2.7
average price	Ft/kWh	3.37		
	Ft/month	3903000		

NATURAL GAS		
heat value	MJ/Nm3	34.28
maximum flowrate	GJ/h	67
demand charge	Ft/GJ/h/month	23333
	Ft/month	1563311
gas cost	Ft/GJ	265

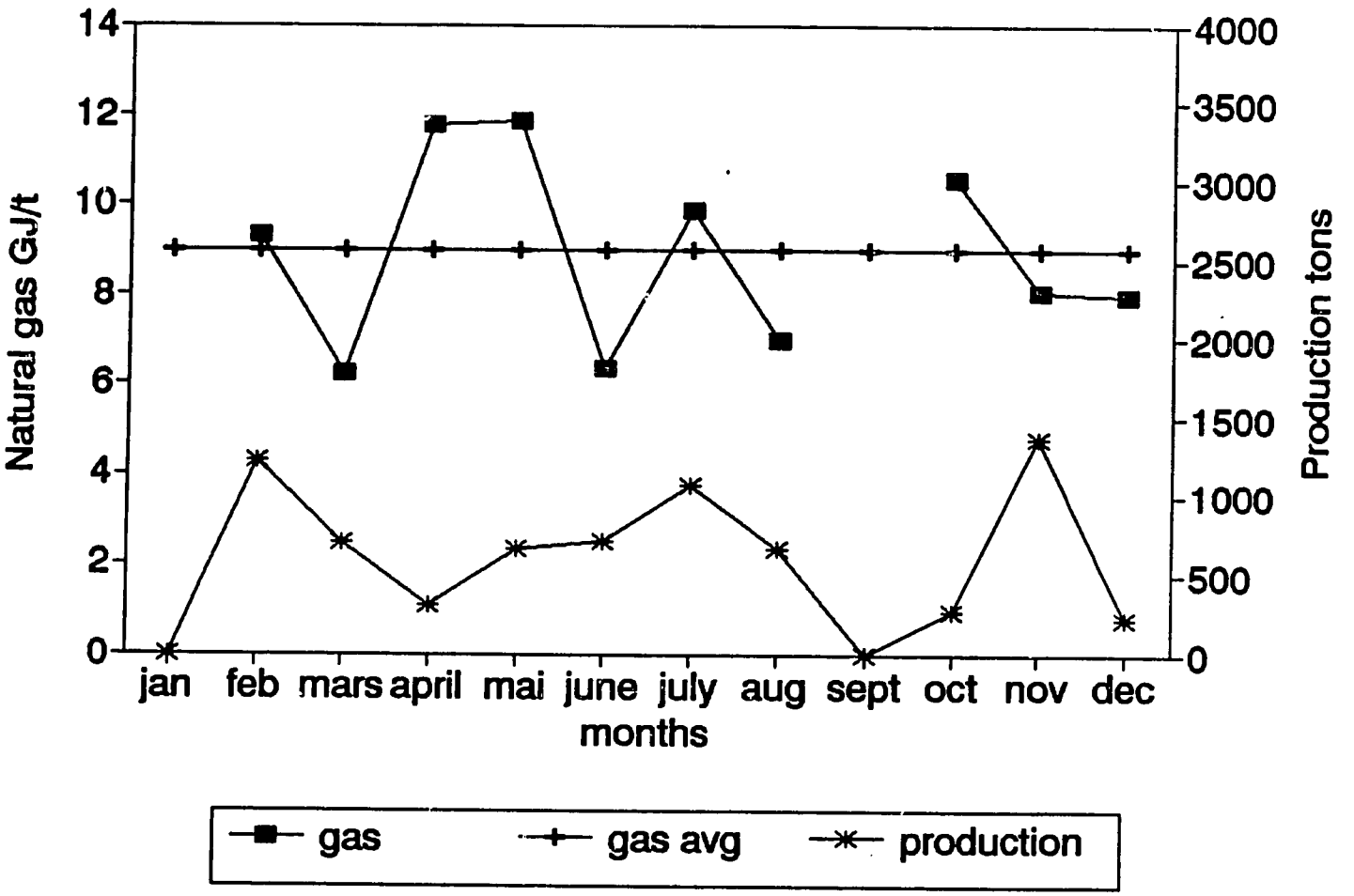
STEAM		
pressure	bar g	5.4
temperature	deg C	238
spheat enthalpy	th/t	700
heat content	GJ/t	3
sat.temperature	deg C	161
sat enthalpy	th/t	658
steam price	Ft/GJ	485
minimum efficiency of boiler		54.6%

COMPRESSED AIR		
pressure	bar g	7
electricity	kWh/000Nm3	100
compressed air	Ft/000Nm3	355

HOT WATER		
pressure	bar g	
temperature	deg C	
maximum demand	MW	26
demand charge	Ft/MW/month	33628
	month/year	7
	Ft/month	874328
heat cost	Ft/GJ	418
minimum efficiency of boiler		63.4%

CSEPEL METAL WORKS - YEAR 1990

Copper Metallurgy - Refining



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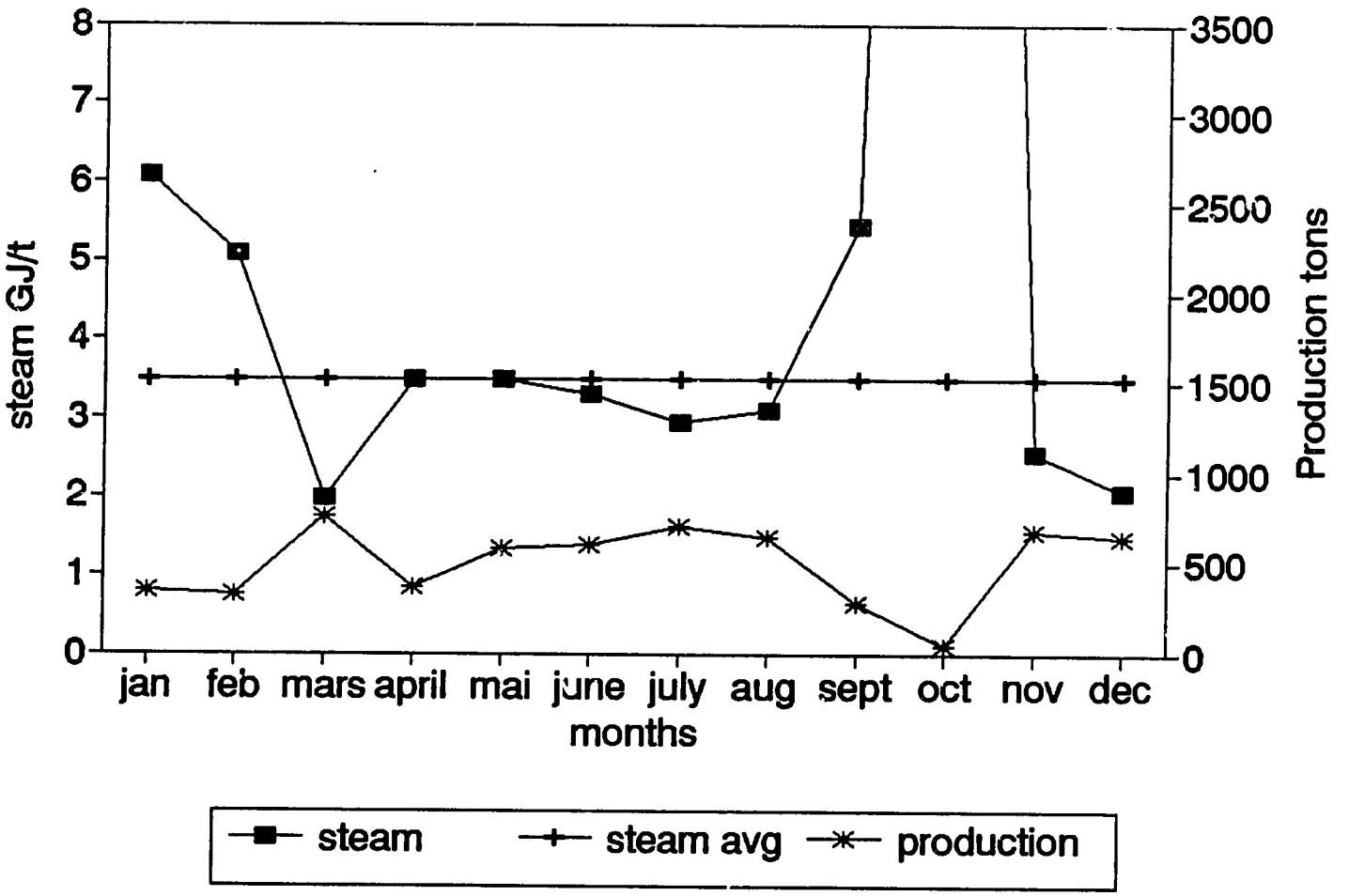
CSEPEL METAL WORKS - YEAR 1990

Copper Metallurgy - Electrolysis



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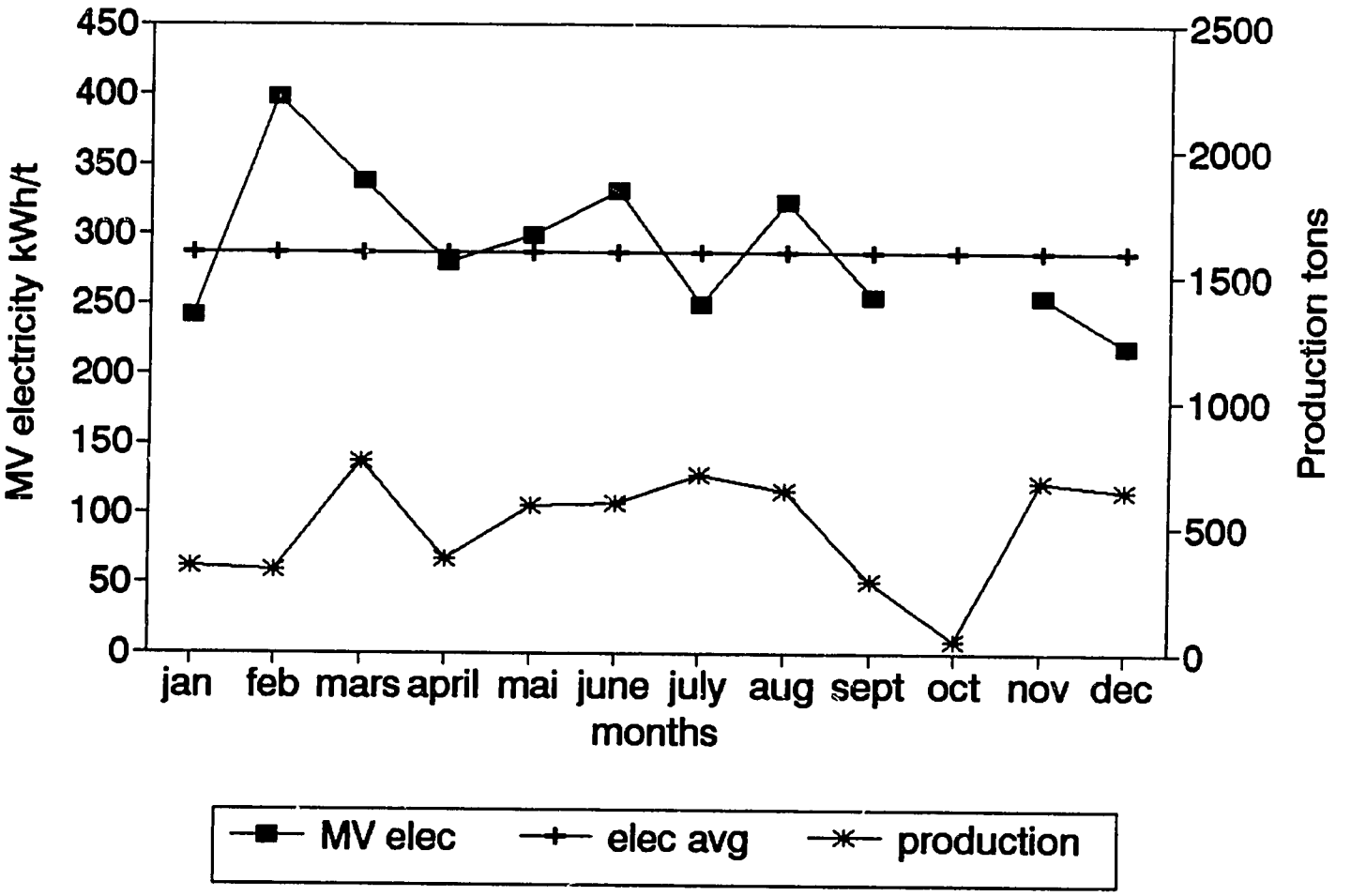
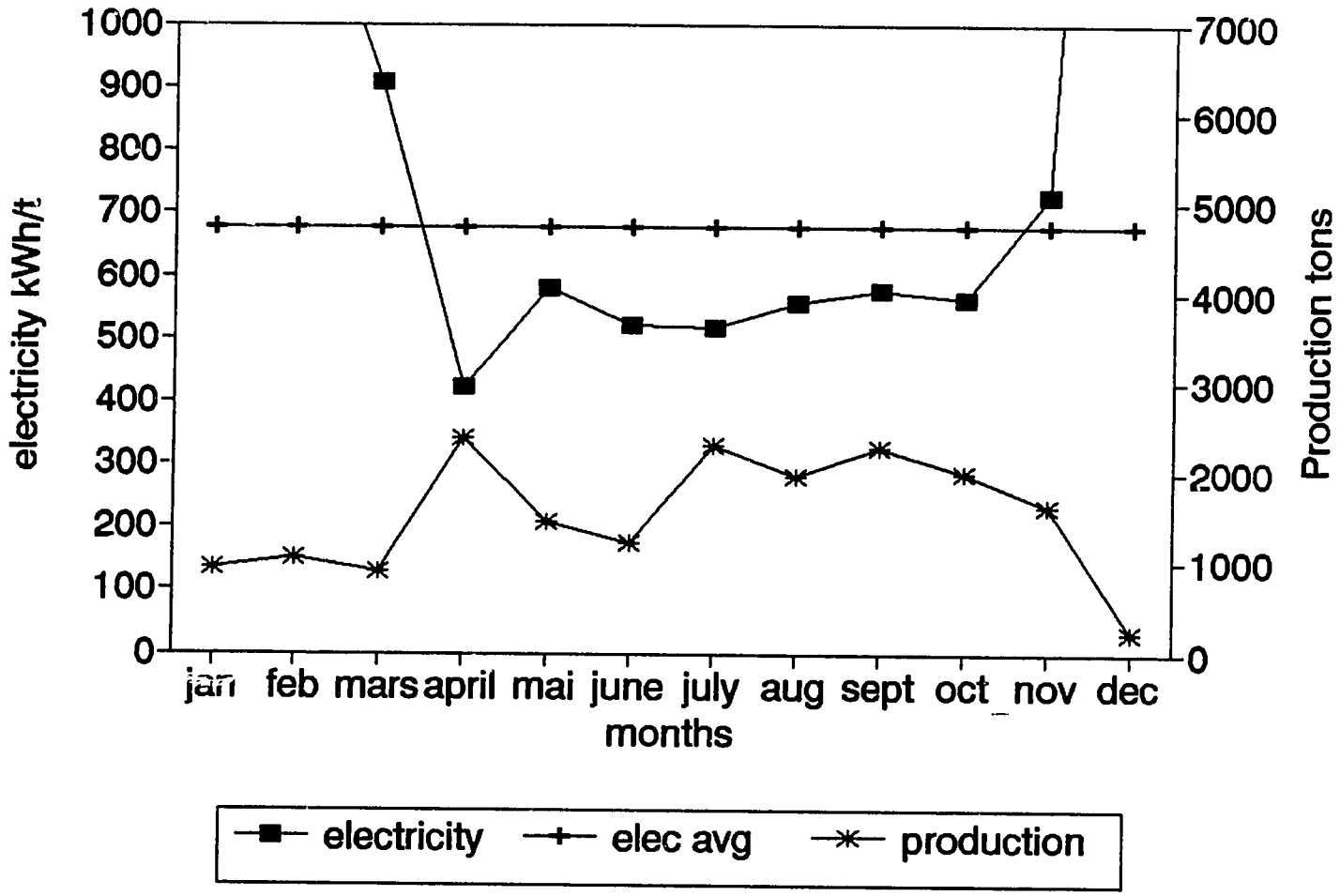
Copper Metallurgy - Electrolysis



CSEPEL METAL WORKS - YEAR 1990

Rolling mill - continous casting



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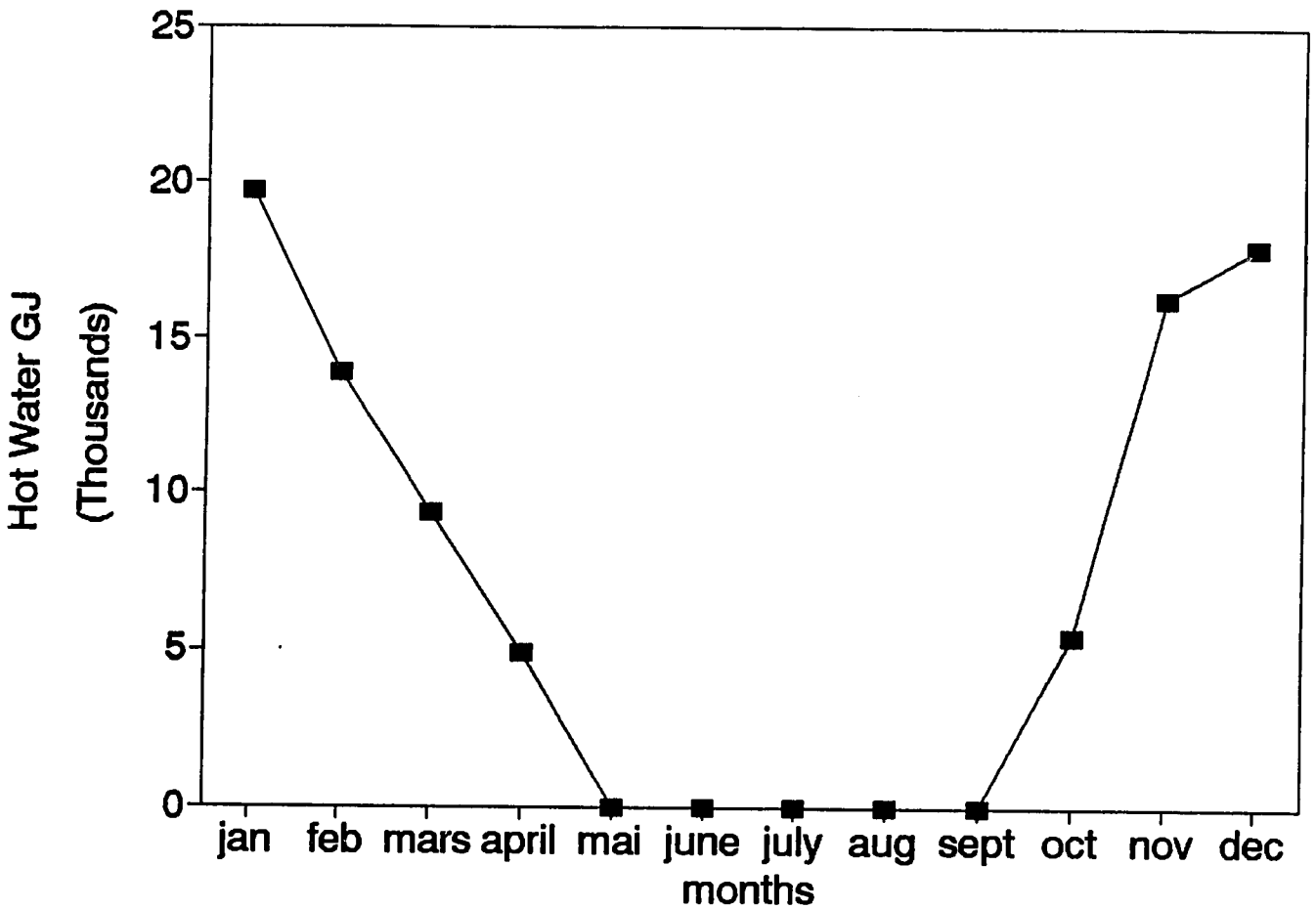
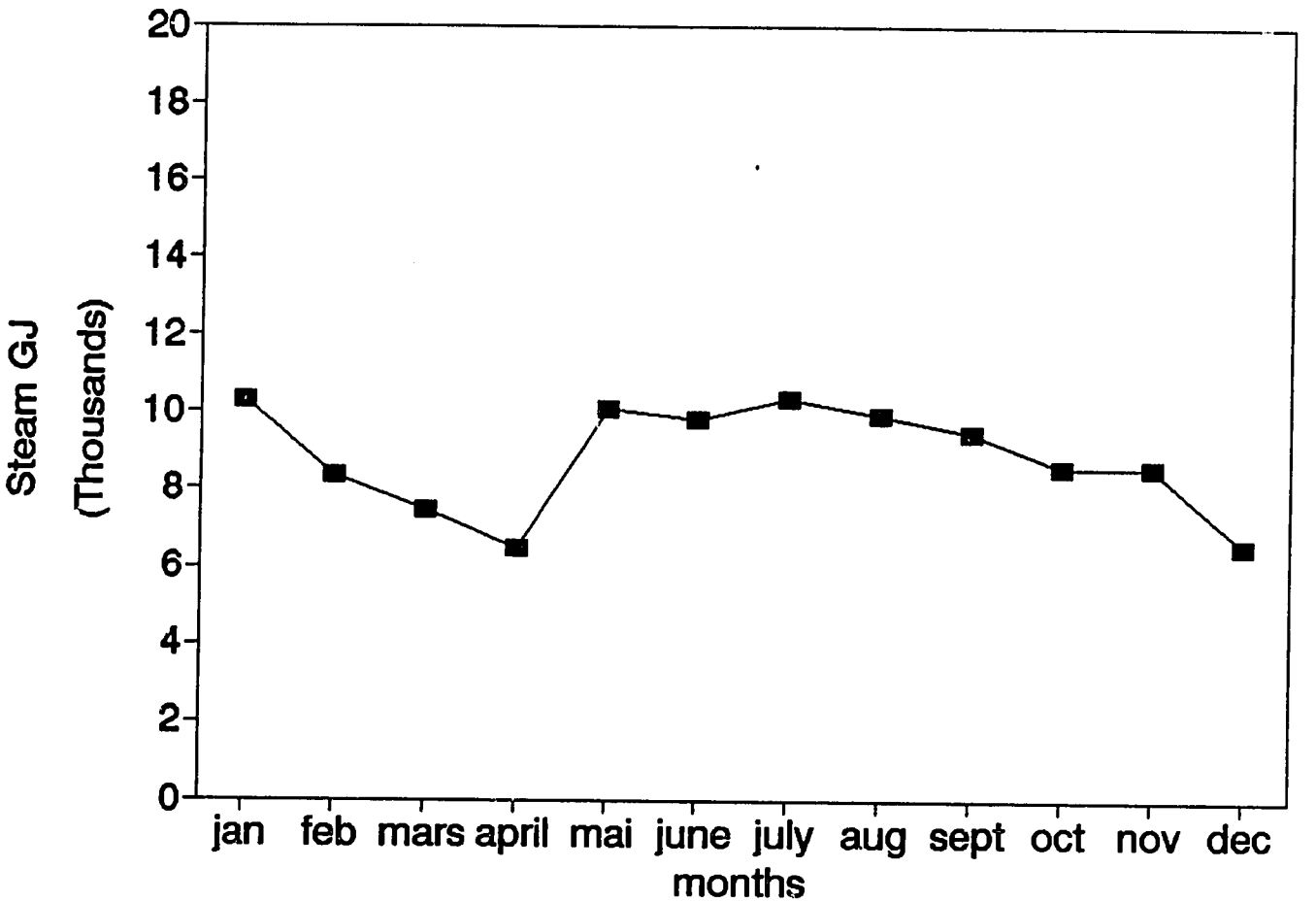
CSEPEL METAL WORKS - YEAR 1990

Hot water consumption



CSEPEL METAL WORKS - YEAR 1990

Steam consumption



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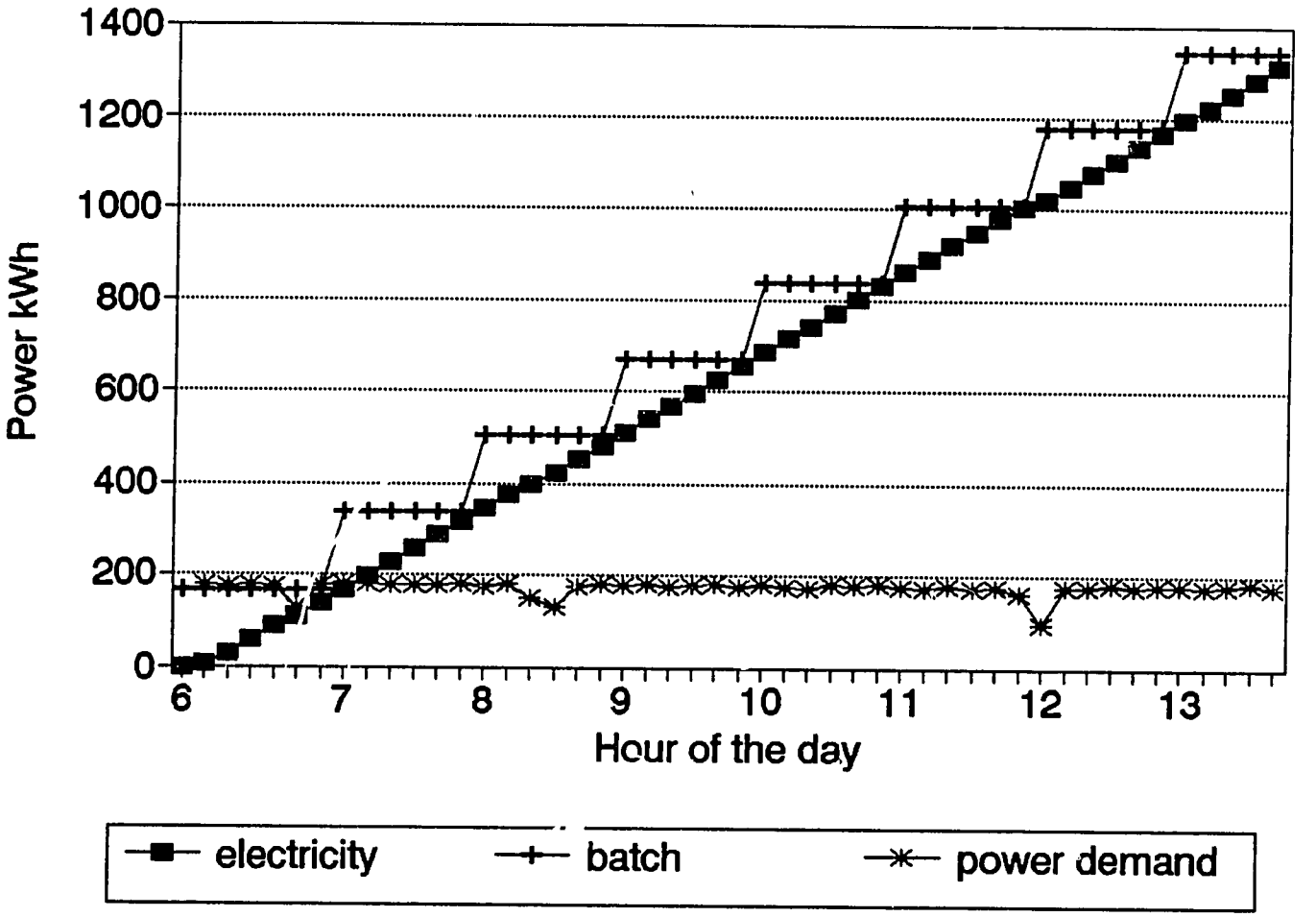

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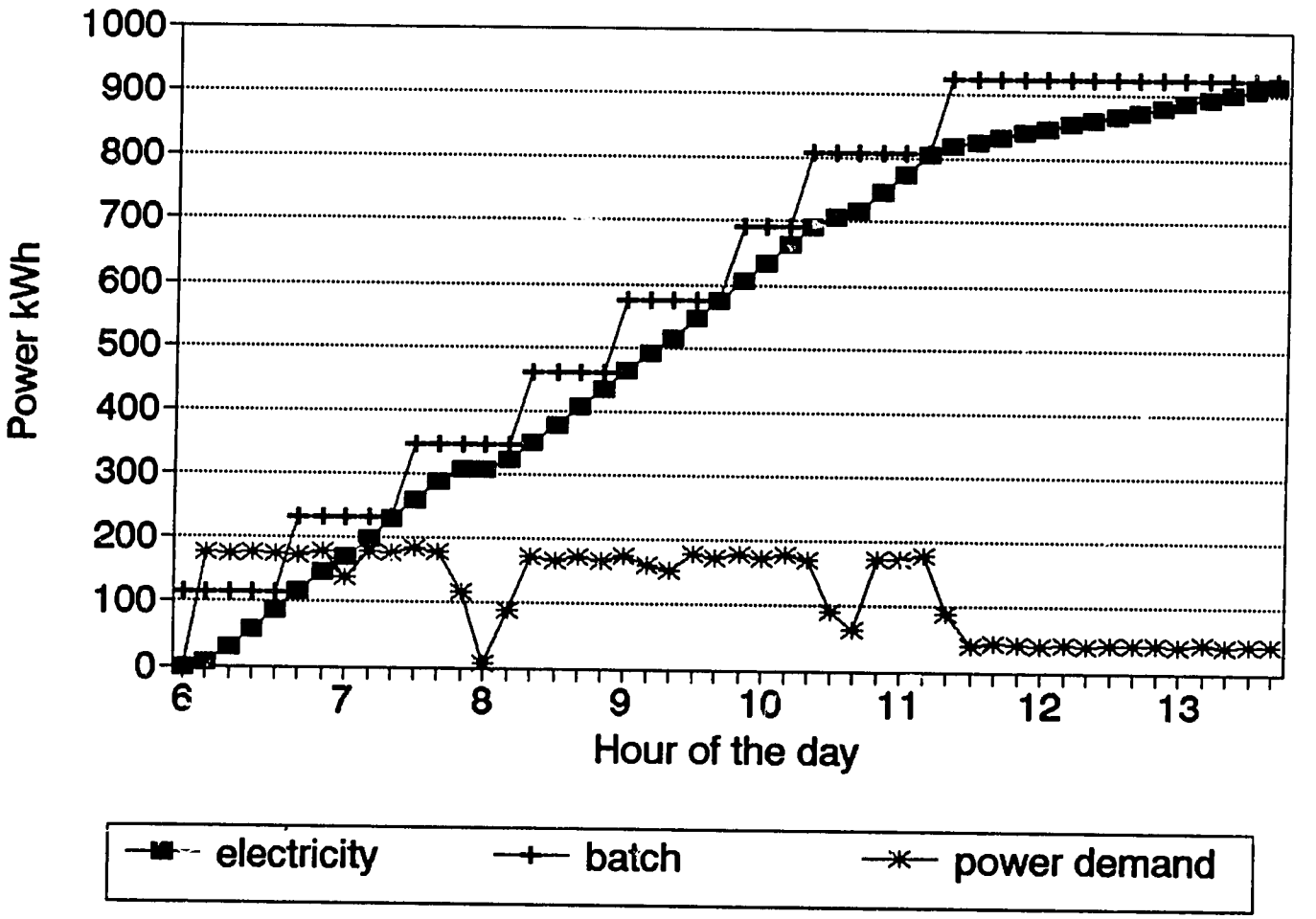

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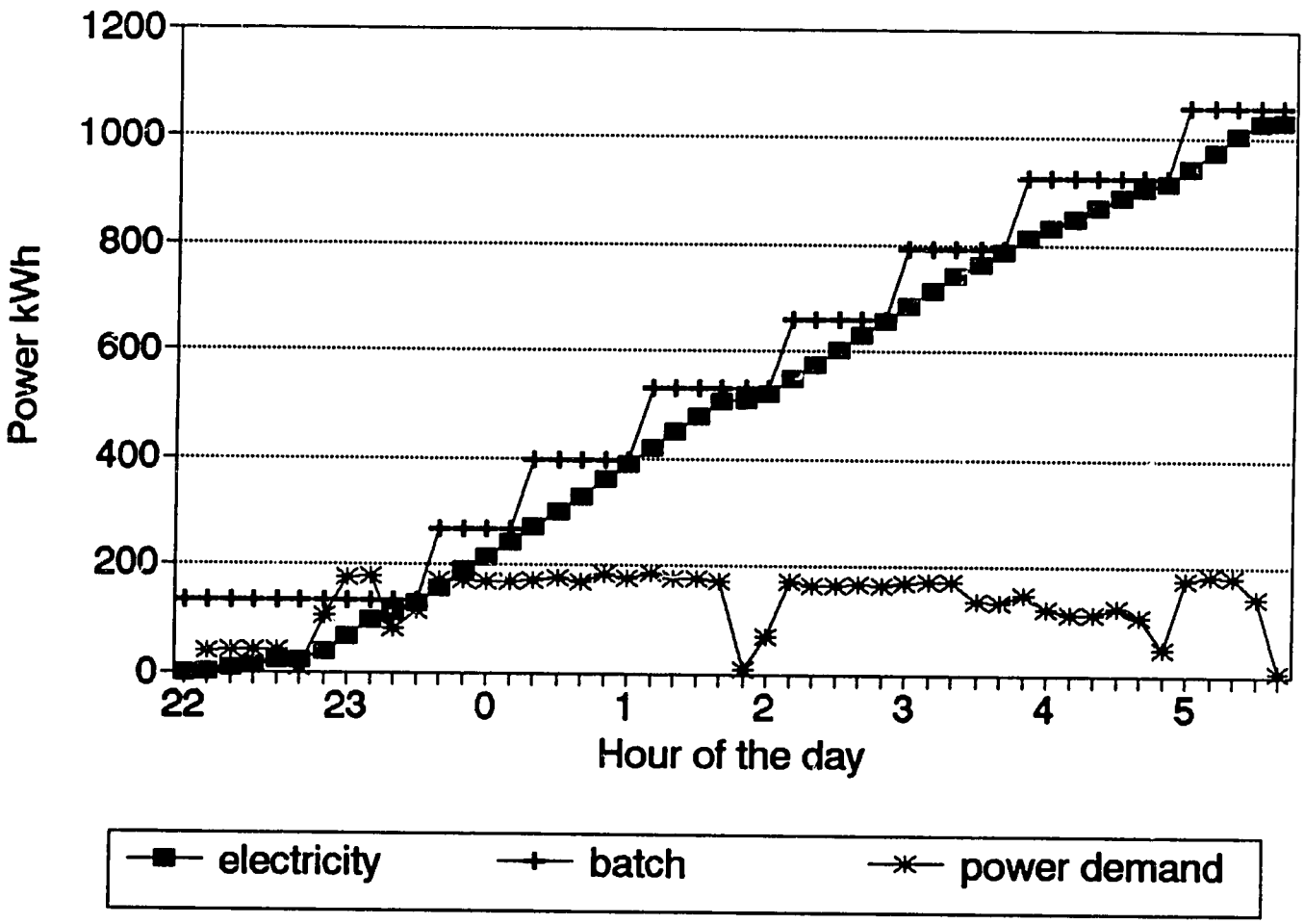

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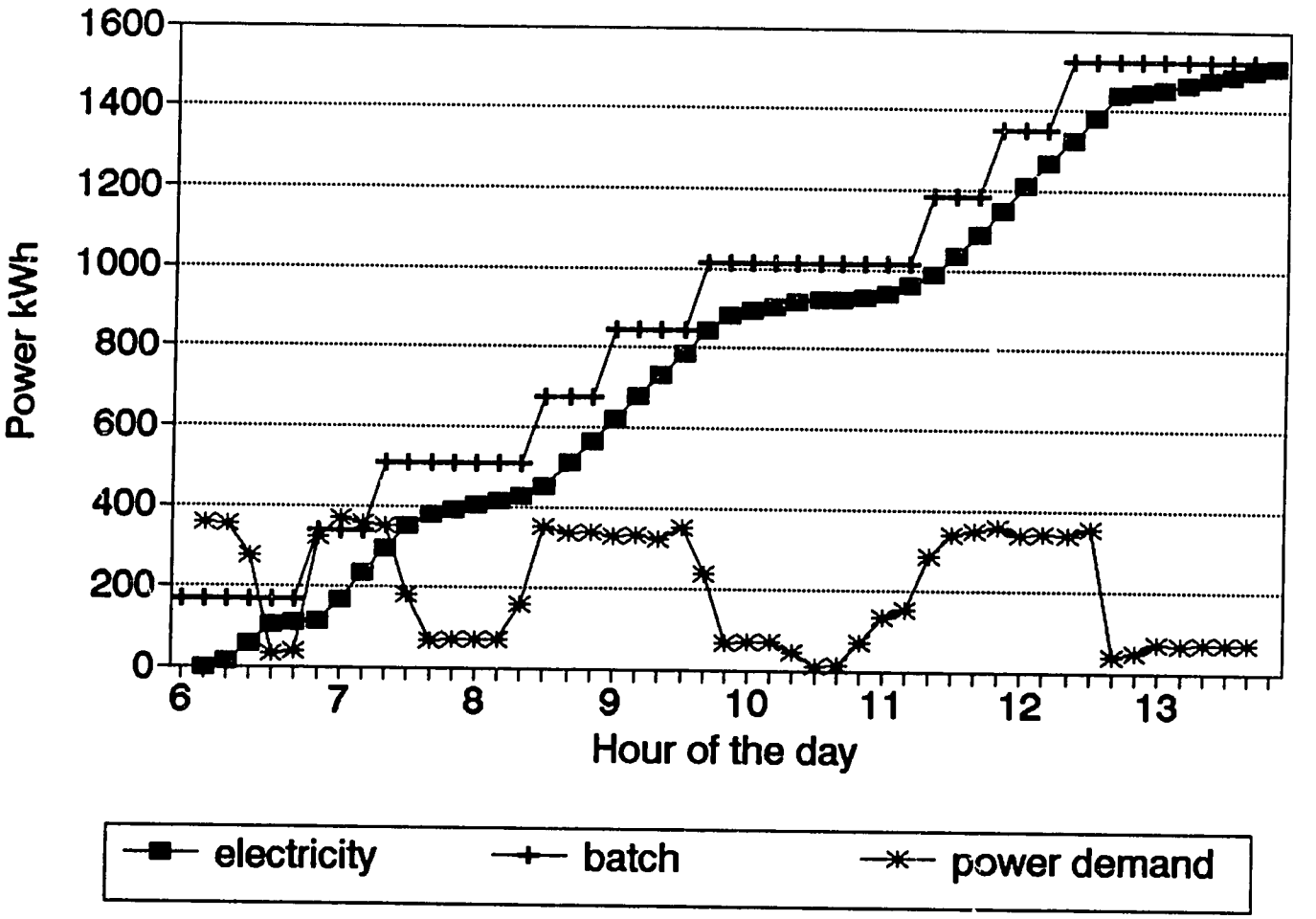

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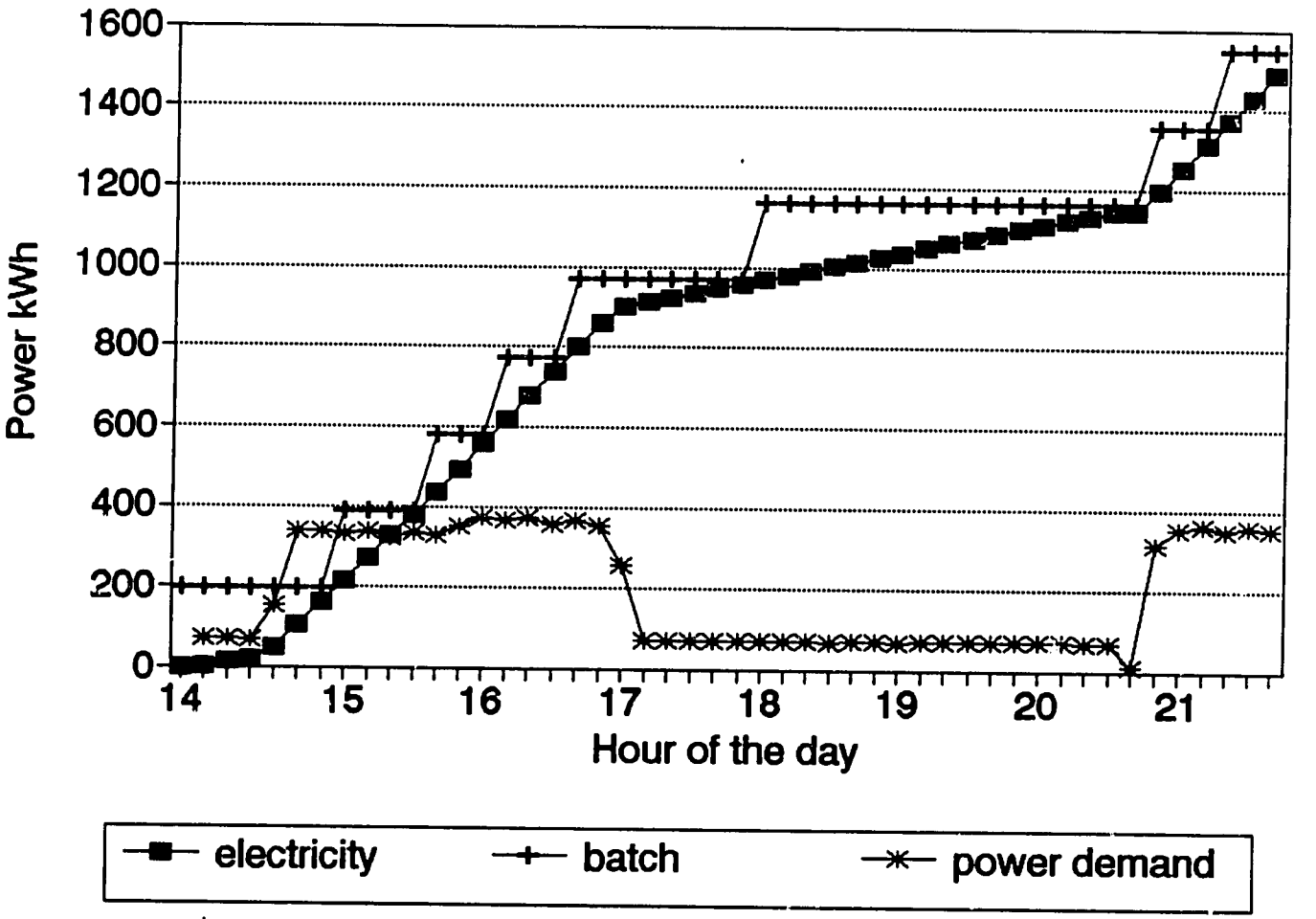

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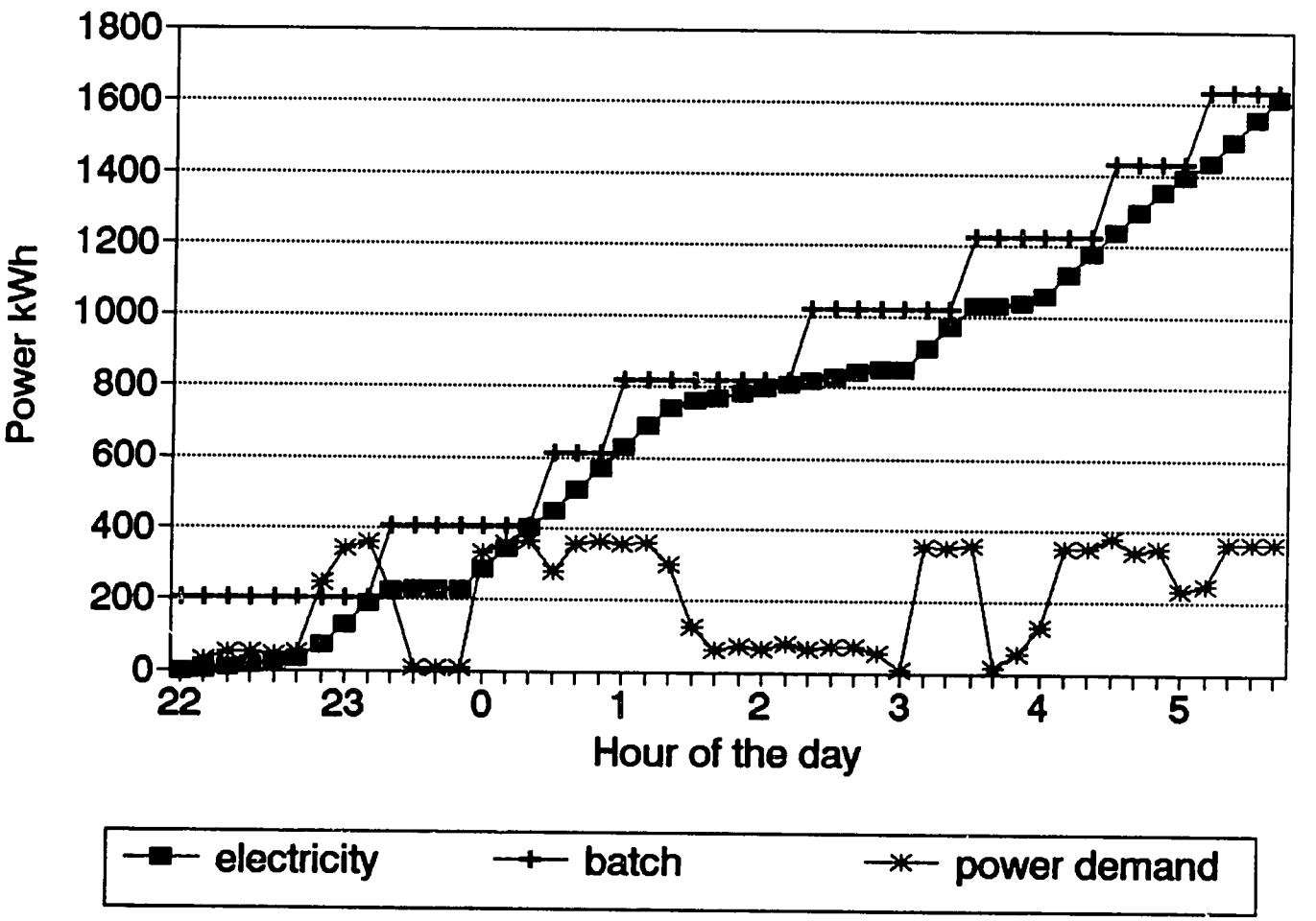
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