5.5 Results of the Study at the Przetworstwa Mleka Factory, MLECZ

(1) Study period: September 22 to 30, 1998

(2) Member of the study team

a. JICA Team

Mr. Yozo Takemura	:	Leader
Mr. Norio Fukushima	:	Leader of energy audit & Heat management
Mr. Shiro Honda	:	Process management
Mr. Jiro Konishi	:	Heat management
Mr. Masashi Miyake	:	Heat management
Mr. Toshio Sugimoto	:	Electricity management
Mr. Akihiro Koyamada	:	Measuring engineering

b. KAPE

Mr. Ryszard Wnuk: JICA Project Manager

c. Local consultants: Warsaw University of Technology

Mr. Maciej Chorzelski	:	Heat management
Mr. Pawet Skowronski	:	Heat management
Mr. Kozyszotf Duszczyr	:	Electricity management

(3) Interviewees

Mr. Janusz Pawliczak	:	President
Mr. Benon Katafiasz	:	Vice President
Mr. Marec Nozny	:	Chief of Boiler
Mr. Jan Wozny	:	Chief of Production
Mr. Mieczyztaw J. Acewice	:	Chief of Milk Powder Department
Mr. Krzyntof Sobieszcryk	:	Chief of Mechanic

5.5.1 Profile of the Plant

(1) Plant name: Zaklad Przetworstwa Mleka, MLECZ

(2) Address: 64-200 Wolsztyn, ul. Zeromoskiego 16

(3) No. of employees: 155
In-house production section: 144

(4) Major products: Milk, powdered milk, butter, cheese

(5) Production capacity: Raw milk receiving capacity : 550 kL/d 200,000 kL/y 260,000 t/y (specific weight 1.03)

Milk production capacity : 250 kL/d (in terms of raw milk)

Powdered milk production capacity: 300 kL/d (in terms of raw milk) 37,080 t/y (product)

Butter production capacity : 2,000 kg/h

(6) Overview of Processes

Raw milk is brought in by tank lorry. In order to manufacture milk products with superior taste, the factory does not depend on UHT (Ultra High Temperature Short-time Sterilization Method 132 °C for 2 to 3 seconds), but rather, adopts the HTST (High Temperature Short-time Sterilization 86 °C for 36 seconds) method. For this reason, they impose a restriction of 100,000 pcs/mL in bacterial count to the raw milk they accept. This milk is brought in from 65 suppliers. The received quantity is weighed, with its temperature kept low by means of circulating chilled water, and sent to the pasteurization process, via a receiving tank. After it is pasteurized to a bacterial count of 20,000 pcs/mL or less, the fat content is removed from the milk by centrifugation, and separated into ingredients for the lines that manufacture butter milk, raw material for cheese, and powder milk, with each of their flow rates being measured. Milk bound for the consumer market are packed as products such as nonfat milk and whole milk. Nylon packs are used as packaging for retail milk, while containers for bulk users are larger. The product tank is also chilled with circulating cooling water to preserve quality.

The plant was introduced from Denmark when it was established in 1988, and it adopts 2 systems of quadruple evaporators. The intermediary product, which is concentrated to about 50 % with this evaporator, is processed by 2 trains of spray dryer, into nonfat milk with 1 to 2 % fat, and fat powdered milk with a 26 % fat content. The quadruple evaporator is kept at a 0.09 MPa vacuum, and facilitates moisture evaporation at low temperature by means of a steam ejector system that uses 0.3 MPa steam. 1.3MPa steam is used for the spray dryer, and by exchanging heat with air by means of heat exchanger, 170 °C hot air for drying is obtained, turning the concentrated milk into powder milk. The powdered milk is stored in a storage tank that is kept under 30 °C, then it is packed according to shipping requirements, and shipped out. Packages take the form of 0.5 kg/bag nylon bags, 25 kg cans, and 800 kg bags, and are packed automatically. The butter machine consists of 1 system. Palmette Cheese, a product unique to this factory, is made in an open vat within 24 hours, and preparations are under way to increase the number of automation machines from 1 to 2 units, to stop manual stirring entirely in the near future. For purposes of hygiene, each process is subject to CIP cleaning (concentrated chemical cleaning method) once a day. Ice cream is manufactured at a separate company. The production plant consists of 2 independent buildings ; the ordinary milk plant and powder milk plant. Products such as milk, butter, and cheese are made at the ordinary milk plant, while acceptance of raw milk and production of powdered milk are conducted at the powdered milk factory. Waste water is processed by the activated sludge process, and MLECZ pays the processing cost.

The boiler supplies steam to a plant constructed 500m away, and some of the steam is also supplied to the city for heating. The main process is shown in Figure 5.5.1. The pasteurization process diagram is shown in Figure 5.5.2.

Figure 5.5.1 Process Flow

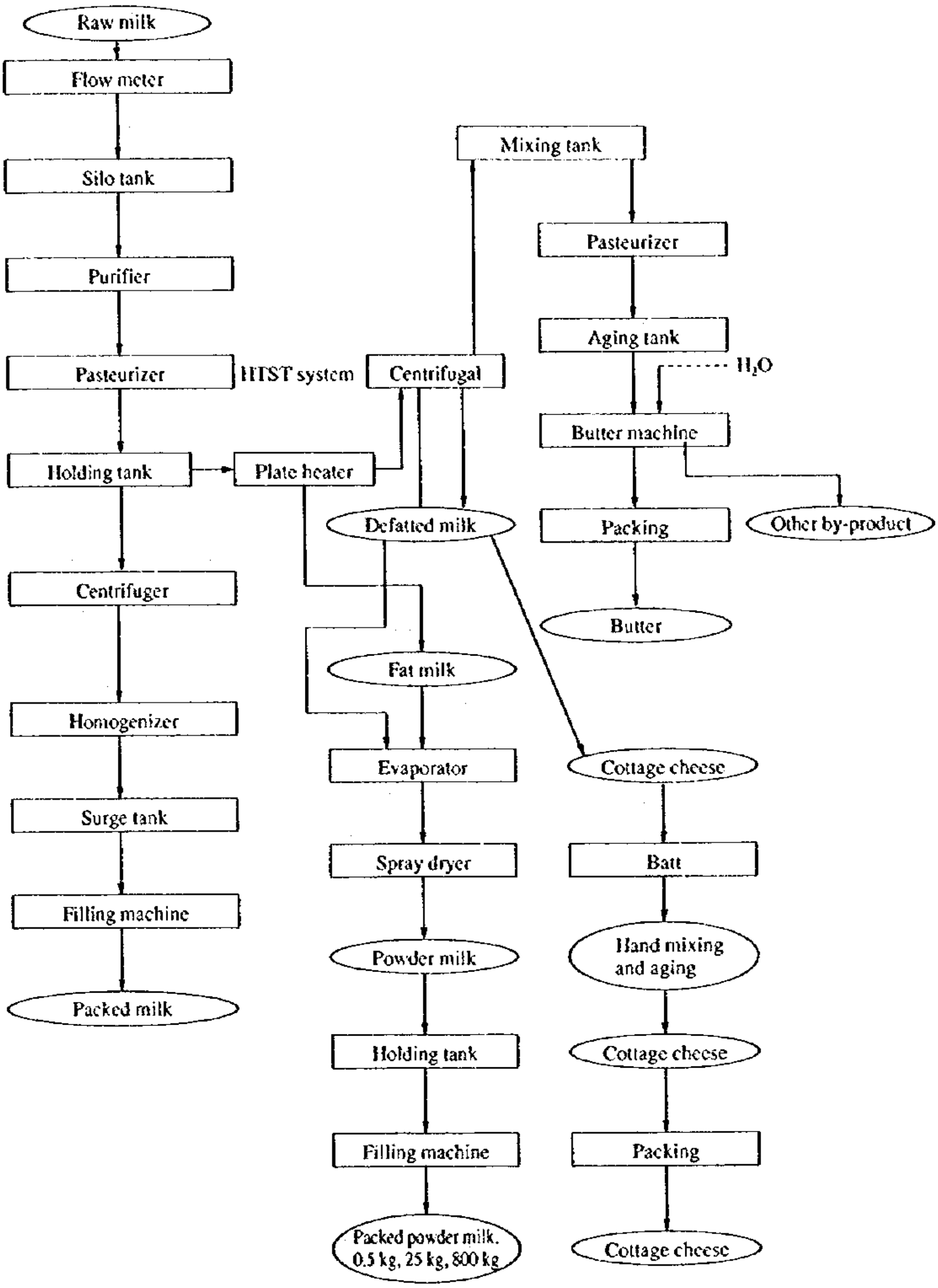
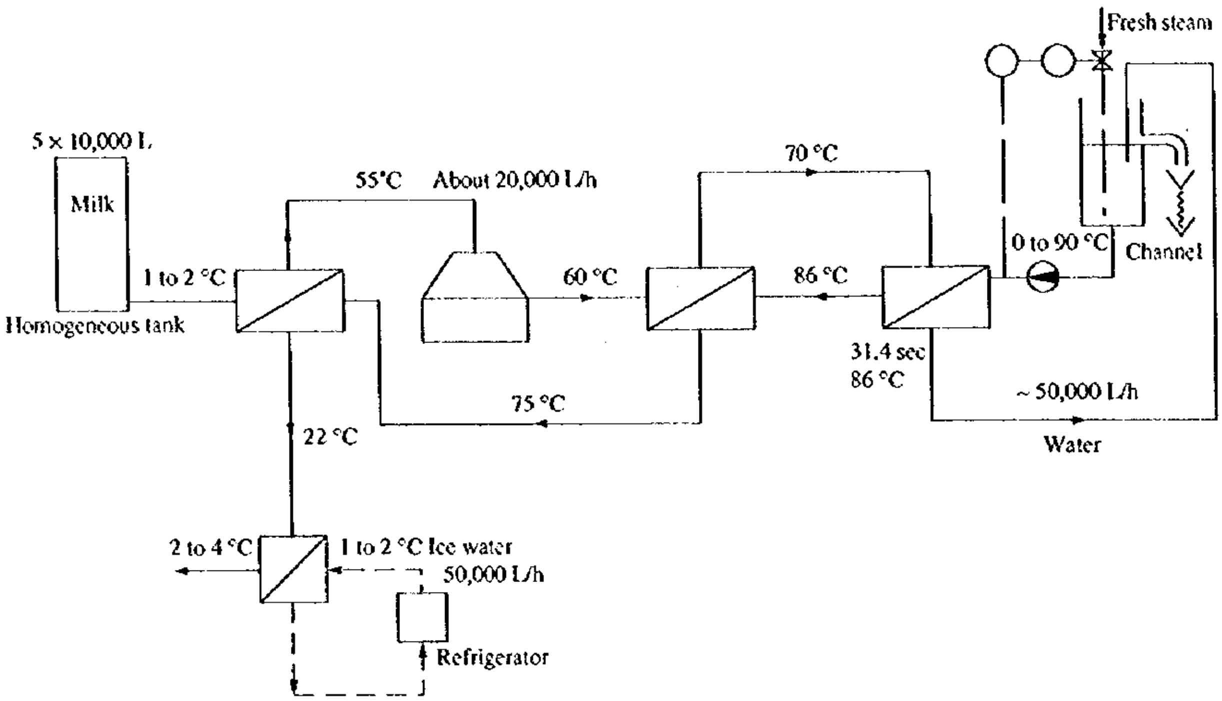


Figure 5.5.2 Pasteurization Flow of Milk



(7) History & Outline of the Plant

1978: Construction Committee set up at request of Dairy Cooperative Association
1988: Construction of plant capable of handling 550 kL/day of raw milk completed; operation commenced
1993: New organization formed; currently a limited liability company; principal shareholder LACPOL holds 99 % of stocks

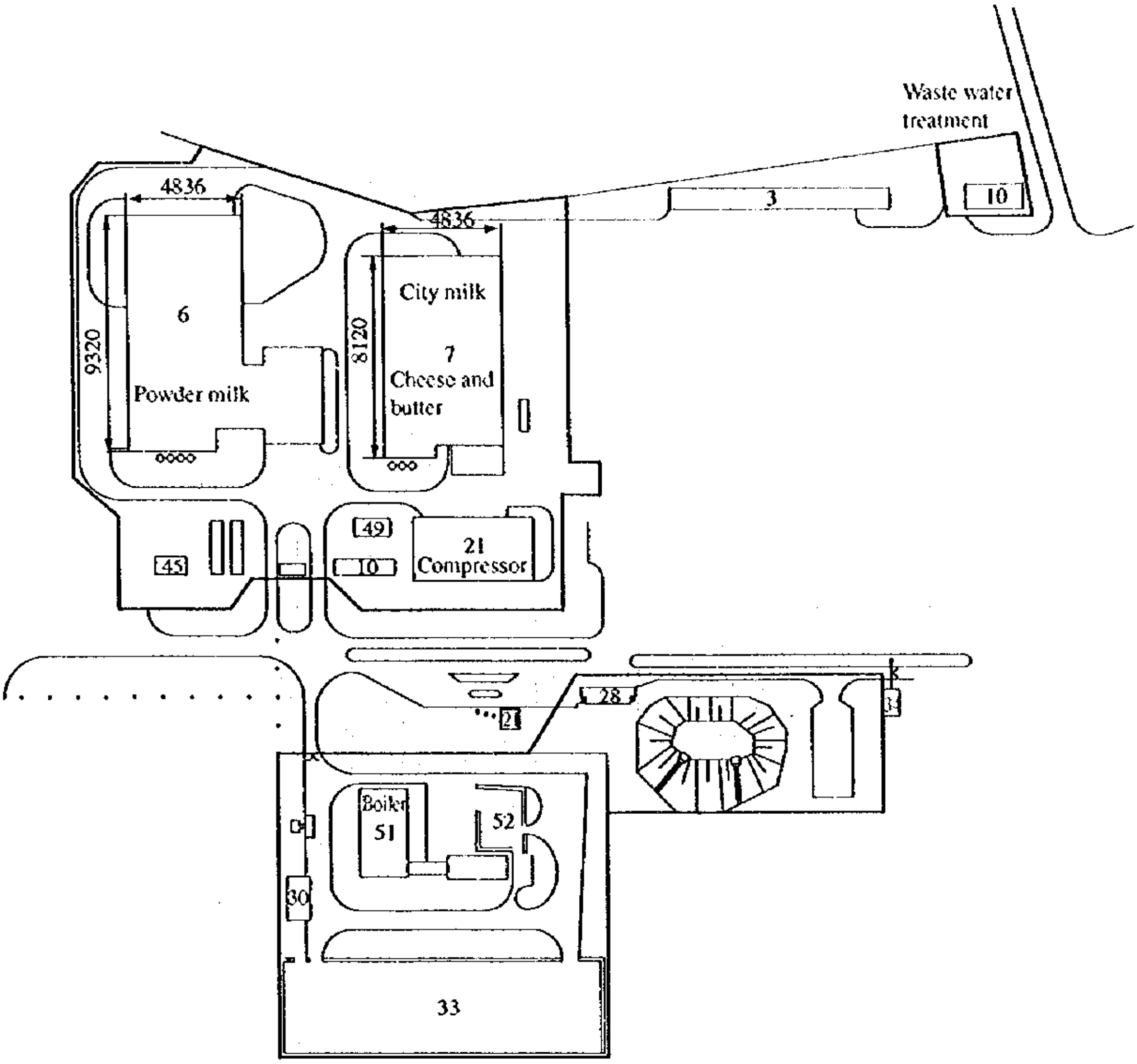
The plant has a milk reception capacity of 200,000 kL/year, but currently is operating at a level of only 70,000 kL/year (200 kL/day). Demand has failed to grow since the collapse of the Soviet Union, and the plant's operation rate has sunk to 36 %. Mlecz's parent company, the dairy corporation LACPOL, is the third-largest dairy business on the Polish market.

Of the 20,000 tonnes of dairy products produced by the company per annum, city milk accounts for 50 % and powdered milk for 22 %, while the remainder consists of butter and cheese products (e.g. cottage cheese) produced by the milk plant. As shown inTable 5.5.3, the company is eager to acquire ISO-9000 and introduce HACCP (Hazard Analysis Critical Control Point), but due to deficiencies in the screen air intake method used at the powdered milk plant, the products do not meet the EU's hygiene standards, and the company is thus unable to export to EU countries. Its share on the Polish market is 1~2 %, and it also exports powdered milk to South American countries and Egypt.

The company is currently experiencing difficulties in obtaining sufficient supplies of raw milk from nearby suppliers, owing to the break-up of state-owned dairy farms.

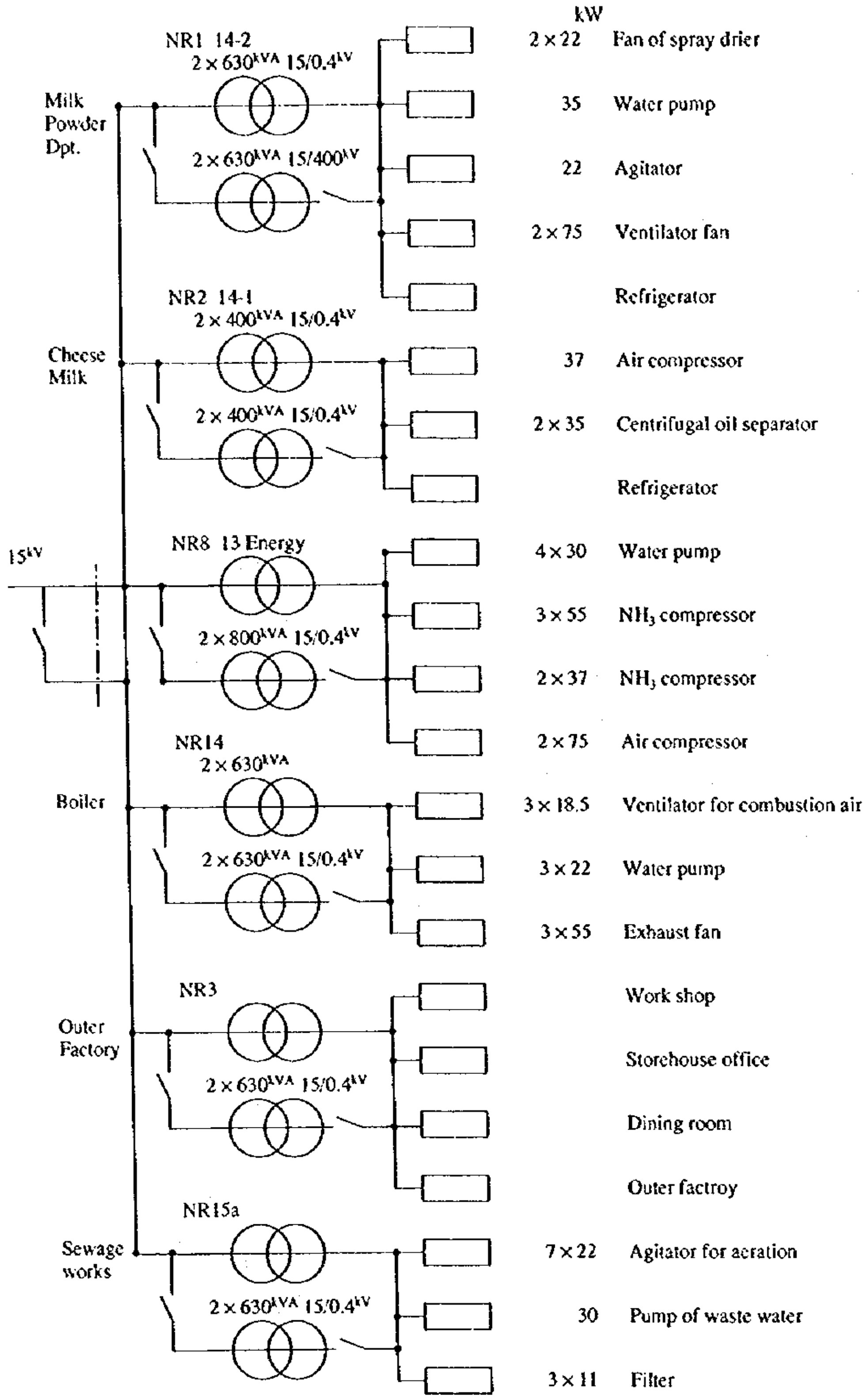
(8) Plant layout

Figure 5.5.3 Plant Layout



(9) One line diagram

Figure 5.5.4 One Line Diagram



(10) Outline of major equipment

Table 5.5.1 Major Equipment

	Number	Specificaition	Maker	
Milk receiving process				
Raw milk receiving tank	6	5,000 L × 3 × 2	Lubolslco Folrylac Wog	made in Poland
Pasteurizer	2	100,000 kL/y × 2 86 °C	Nagewa DDR	made in Denmark
Powder milk process				
Evaporator	2	8,000 L/h, 7,500 L/h	Dounwerd Apv Anhydro	made in Denmark
Dryer	2	1,200 L/h	Dounwerd Apv Anhydro	made in Denmark
Packing machine of milk powder	2	0.5 kg Pack/Bag × 1	Matam Halord	
		25 kg Pack/Bag × 1	Rove mA Germany	
Butter, cheese				
Butter packing	1	2,000 kg/h	Creely	made in Poland
Cheese	9	2,500 kg × 8, 10,000 kg, aging type		made in Poland
Utility				
Freezer	1	40 kW, 60,400 kcal/h, 20 RT	Dabico	made in Poland
	4	48 kW, 2 - 4 °C, 97,440 W		
Compressor	2	10 atm, 150 °C, 50 %, 75 kW, 10 - 12 h	Crepelle Frouce 1990	
	4	7.5 kW × 1, 5 kW × 4		
Boiler	3	10 ton/h, coal, Air preheater, 13 kg/cm², 1 set, Resting Reducing 3.5 kg/cm²		made in Poland
Waste water treatment pond	1 set	53 m × 53 m 3 m, 22 kW × 5		made in Poland
	3 sets	in another factory & city waste water, 5.5 ha		
Dry milk silo	7	inside		
Raw milk silo	6	outside		

(11) Energy prices and heat value

Table 5.5.2 Energy Price and Heat Value

	Energy price	Heating value
Coal	0.155 PLN/kg	21.5 GJ/t
Electricity	0.160 PLN/kWh	10.256 GJ/MWh

5.5.2 Status of Energy Consumption

(1) Production Volume Trends

As stated above, production volume is currently running at only 30 % of equipment capacity. Table 5.5.3 shows a breakdown by product category of production from 1993 to 1997. While there has been no major change in overall production volume last year or this year, the ratio of powdered milk production has been rising. Table 5.5.4 shows the ratios to total production in the period 1993~1997 of the major product categories - milk, powdered milk, and butter. Production of full-fat powder milk has been increasing recently, which has caused an increase in the volume of cleaning water used in the dryers.

Table 5.5.3 Trend of Production (t/y)

	1993	1994	1995	1996	1997	1998 (January to August)
Raw milk	43,183	39,566	46,113	66,667	67,219	47,295
Production	12,955*	11,870*	14,965	18,755	20,266	14,189
Milk	4,781	8,503	8,196	9,938	9,882	(including products which contain 42 % protein)
Powder milk	2,239	772	2,036	3,585	4,198	Low fat, Full fat
Butter	764	945	1,242	1,381	1,941	
Cheese, etc.	5,170	1,650	3,491	3,851	4,245	Cheese, whey, etc.

* The values for 1993 and 1994 indicate those for the previous organization.

Table 5.5.4 Trend of Production Ratio of Main Product

Year	Production	Milk		Powder milk		Butter	Concentrate	Total
	t	2 % fat	Products containing 45 % protein	Low fat	Full fat		75 % (Quasi-cheeze)	
1993	7,833	56.5 %	4.5 %	28.8 %	0.2 %	9.7 %	0.6 %	100 %
1994	10,270	74.8	8.0	6.9	0.5	9.2	0.5	100
1995	11,547	69.1	1.9	16.0	1.6	10.8	0.6	100
1996	14,344	65.9	3.4	18.1	2.7	8.6	0.3	100
1997	16,049	59.9	1.7	13.3	12.8	12.1	0.2	100

(2) Trends of Energy Consumption

Table 5.5.5 Trend of Energy Consumption

Unit		1993	1994	1995	1996	1997	1998 (January to August)
Coal	(t)	5,540	4,064	4,450	6,324	6,250	4,039
Electricity	(MWh)	8,632	10,494	7,190	7,352	5,085	3,840

Steam: 2.8 GJ/t, 1.6 MPa/210 °C, 0.35 MPa/165 °C

(3) Trends in Energy Intensity

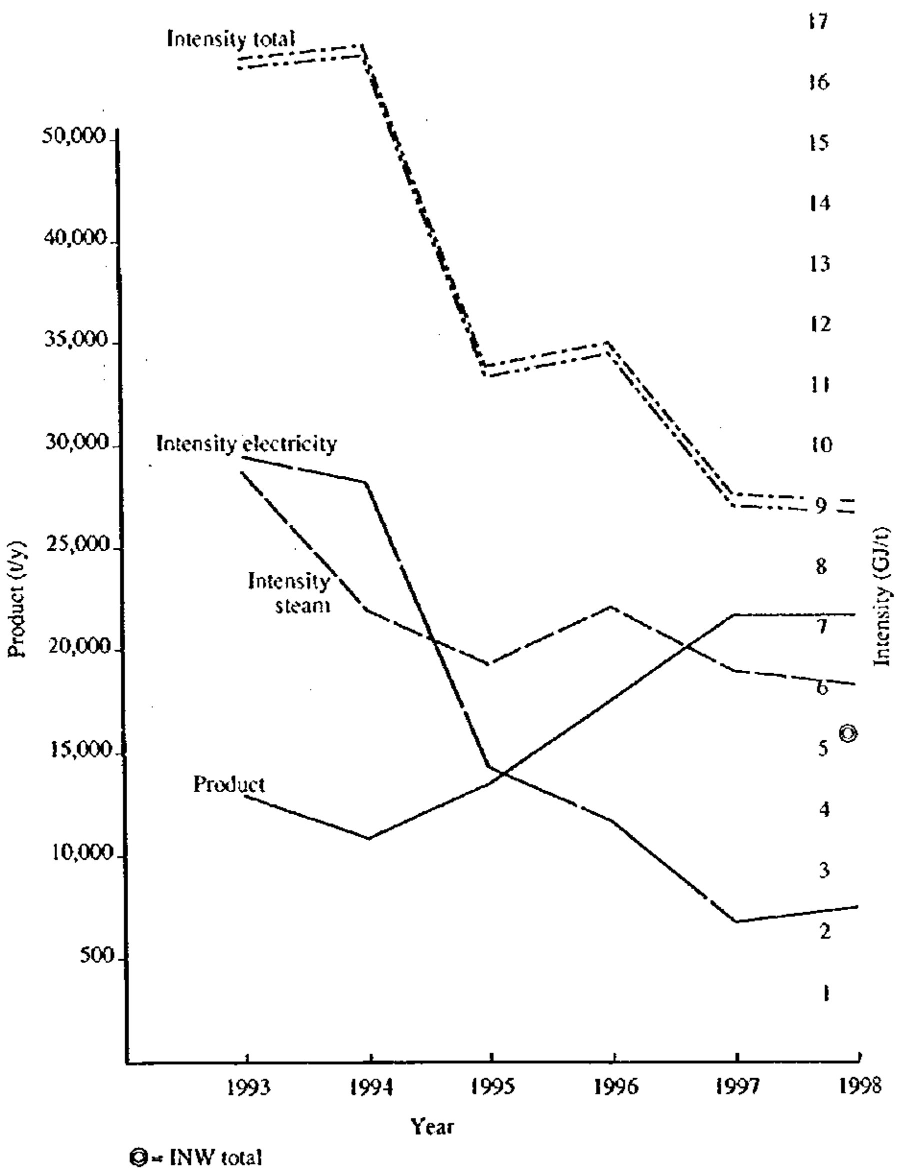
Under the company's new management, the energy intensity has been improving since 1994. The particularly impressive improvement in the electricity intensity is estimated to have been due to energy conservation activities and a rise in the ratio of powdered milk production.

Table 5.5.6 Trend of Energy Intensity

Unit		1993	1994	1995	1996	1997	1998 (January to August)
Coal	(t)	5,540	4,064	4,450	6,324	6,250	4,039
Steam	(GJ)	119,142	87,400	95,700	135,995	134,399	86,846
Electricity	(GJ)	88,547	107,647	73,755	75,416	52,162	39,391
Intensity	(GJ/t-product)						
Steam		9.19	7.36	6.39	7.25	6.63	6.12
Electricity		6.83	9.06	4.93	4.02	2.57	2.78
Total		16.02	16.42	11.32	11.27	9.20	8.90

1 MWh = 10.258 GJ

Figure 5.5.5 Production & Intensity



(4) Energy Flow

Steam is utilized in the evaporators and spray dryers at the powdered milk plant and in the pasteurization of raw milk supplies received. In winter, steam is also used to heat the offices and is supplied to the Heat Supply Center of Wolsztyn City.

A great deal of electricity is used in powering the compressors used in refrigeration, the air compressors, and the waste water treatment equipment.

Figure 5.5.6 Fuel Energy Flow

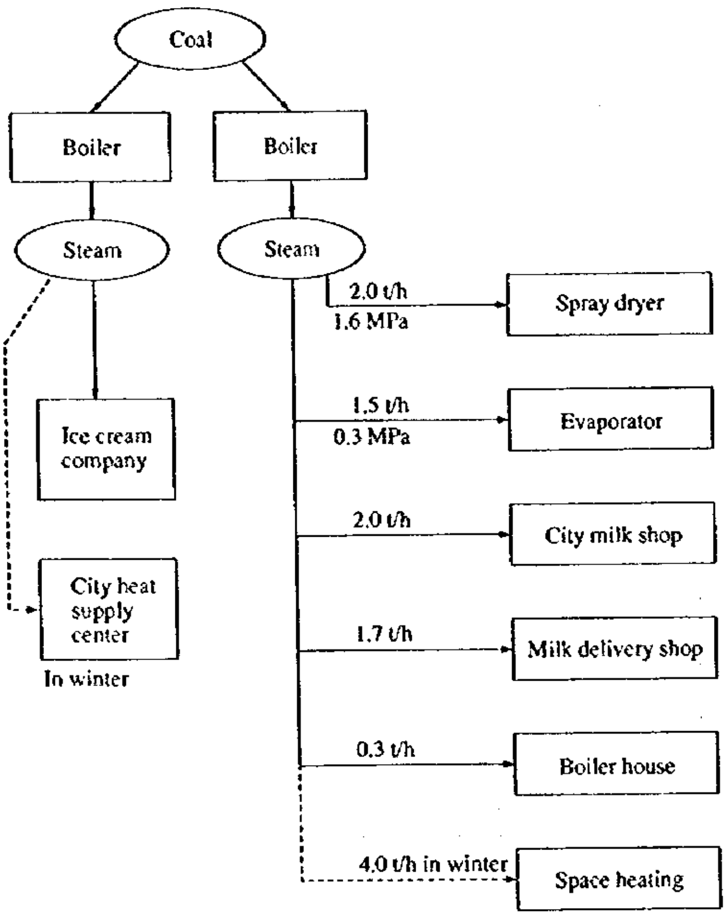


Figure 5.5.7 Electricity Energy Flow

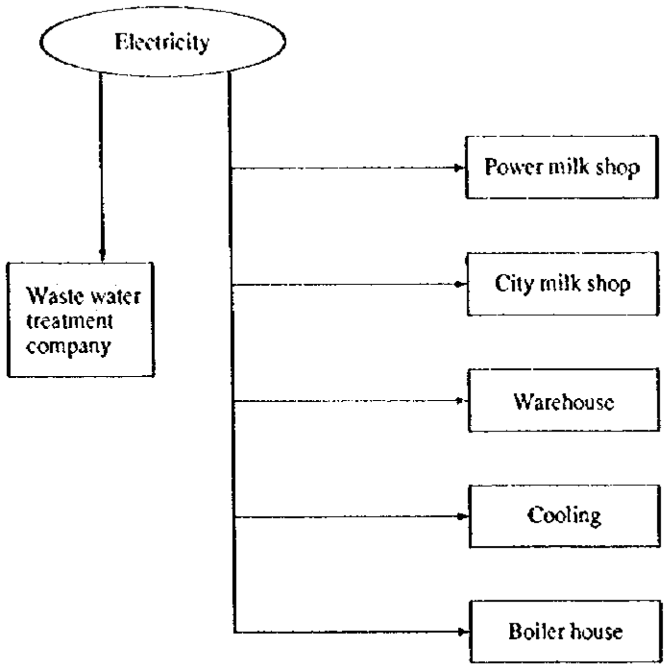
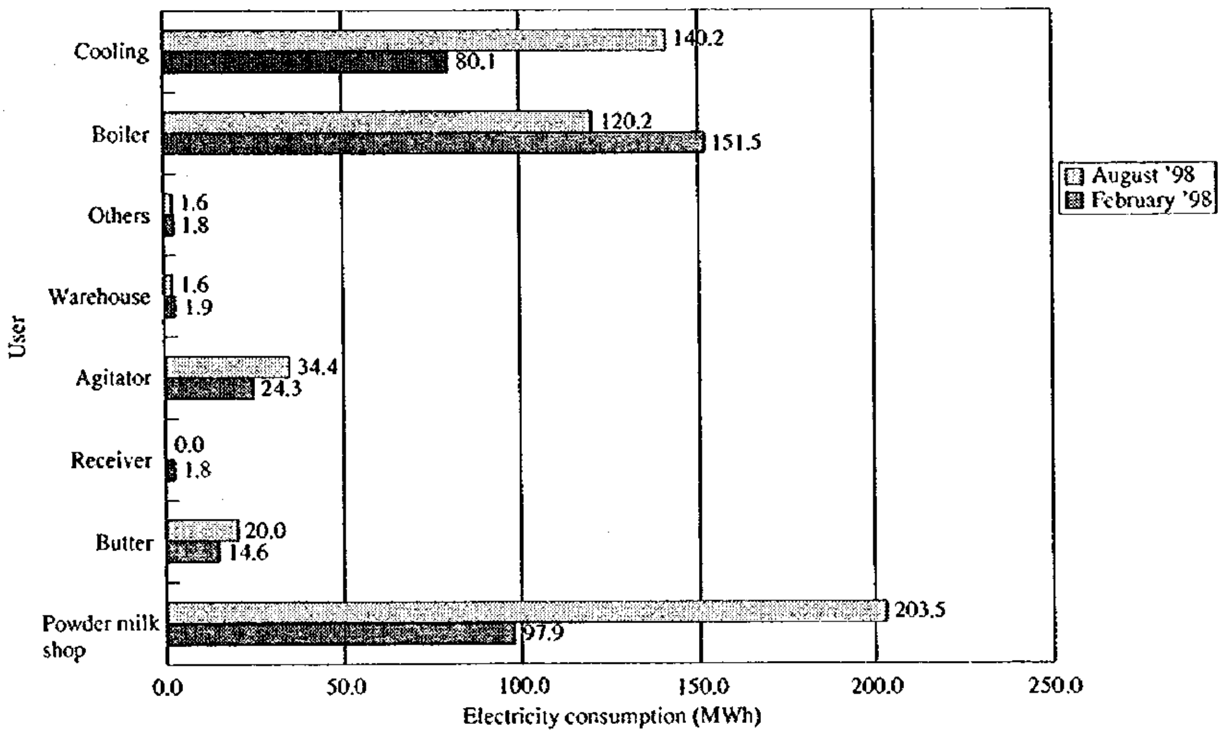


Figure 5.5.8 Electricity Consumption by User



5.5.3 The Status of Energy Management

(1) Setting of Energy Conservation Targets

a. Setting of target values

The data on energy consumption is known, but no target values for energy intensity have been set. Such values are essential in order to decide measures for the improvement of energy conservation. At the cost management meetings held every month, the energy intensity for the month are compared with those for the previous month, and in the event of a deterioration in energy intensity, the causes are investigated and appropriate countermeasures discussed.

(2) Systematic Activities

a. The Establishment of a Dedicated Energy Conservation Section

No dedicated energy conservation department is available. Although cost management meetings are held every month, it is recommended, in addition, that a specialist energy conservation section be established so as to enable the collection of more data and the study of energy conservation technology. The pursuit of energy conservation by the whole company would be very effective. As there are many aspects of energy conservation that require technical discussion, in addition to the Production Division, a number of technical staff members should be selected and charged with the full-time task of supervising energy conservation activities. Moreover, it is important that the data of actual achievements for each month be compared with the target figures and shown in graph form, enabling the company to check the effect of measures against the plan.

b. Management Stance

The company's management appear to be strongly motivated to achieve cost savings and energy conservation. For several years, they have requested universities to carry out energy audits, and have been taking measures to improve the situation. As the company pays the Dairy Cooperative Association the cost of processing its waste water, plus a fee, the management have been devoting their energies to finding ways of reducing the amount of electric power used by the waste water processing plant.

The management are very eager to implement improvements. They are faced with the need to simultaneously develop new products, find exports markets, and particularly to devise ways of obtaining permission to export to EU countries and implement quality control, while on the other hand they appear to be in some doubt as to how to go about promoting energy conservation. They are currently discussing the conversion of the boiler fuel to natural gas, ways of reducing the cost of waste water processing, and the replacement of the air compressor in the machine room with a smaller model. Packing is carried out using an open system, which means that the products are likely to be contaminated with impurities. For this reason, the management are debating measures to bring the plant into closer conformity with food processing plant standards by installing devices to exclude impurities, among other measures.

The energy conservation measures put into practice in 1997, including checks on energy intensity at the cost management meetings, strict enforcement of turning off unnecessary lights during the day, implementation of electric power demand control using a power demand monitoring device, and the checking of the power factor of electric equipment, have been carried out under the overall guidance of the company's president. As a result, electricity intensity has been greatly improved.

(3) Data-based Management

a. Monitoring Energy Consumption

Since the company's reorganization in 1994, the departments under the direct control of the president - accounting, general affairs, and sales - have been located on the same floor, making for easier supervision, and major decisions are taken by the president himself. Ledgers are properly provided for the entry of production and sales statistics, and for the purchase of raw materials (including materials other than raw milk). Consequently, the company now has a clear grasp of the amounts of energy used in the production of each product category.

b. Monitoring Energy Consumption by Each Major Piece of Equipment

A considerable amount of statistical data is available. Although there is information on the energy intensity for each product made at the plant, this data is of no help in energy conservation activities. Cost data has been compiled for the amounts of heat, electric power and water used, as well as the volume of waste water emitted, by the principal equipment, and estimates can be made from this data. The details, however, remain unclear.

c. Installation of Measuring Instruments

The volume of flow of liquids into and out of the major pieces of equipment is measured. Steam flow volume, however, is not measured, only estimated. Deficiencies were noted in the number of heat and electric power measuring instruments installed. More such measuring instruments will have to be installed to allow the efficient implementation of specific energy conservation measures.

(4) Staff Training

Middle-management staff at the level of section head and above have the opportunity to receive training in energy management from the president at the cost management meetings and on other occasions, but progress has not been made in the education of general employees in the concepts and techniques of energy conservation. Needless to say, management staff must be trained in energy conservation, but the lack of progress in training the shop-floor workers who actually operate the equipment on a daily basis presents a major obstacle to the pursuit of energy conservation activities. Planned promotion of energy conservation at the organizational level is desirable.

(5) Plant Engineering

The state of equipment management at the company is comparatively good. The plant is a new one planned and constructed from 1984, and the machinery has been in operation for only just over 10 years. The spot check and maintenance system is insufficient, and bare steam pipes can be seen at the head of the dryer. As the plant uses coal-fired boilers, the installation of denitration equipment will probably be needed in the future in order to conform with environmental regulations. The company needs to establish a future-oriented policy that includes measures for the costs of pollution prevention while simultaneously aiming at cost-cutting via energy conservation.

5.5.4 Problems and Countermeasures Relating to Energy Use

(1) Comparison of Energy Intensity with an Excellent Factory

We compared the energy intensity of Mlecz in 1997 with that of the model state-of-the-art factory (hereinafter called "Excellent factory".). The results of this comparison are shown in Table 5.5.7. The heat intensity of Mlecz was 1.8 times that of the Excellent factory, while its electricity intensity was 1.7 times. The company thus has great potential for energy conservation.

Table 5.5.7 Comparison of Energy Intensity

		MLECZ	Excellent factory		Difference
Fuel	(MJ/t)	Coal 6,500	Fuel oil 3,600	55 %	2,900
Electricity	(MJ/t)	2,500	1,500	60 %	1,000
	(MWh/t)	(244)	(146)	98 %	
Total	(MJ/t)	9,000	5,100		

(2) Estimation of Energy Conservation Potential

Energy conservation potential is divided into the following three steps:
Step 1: Enhancing management
Step 2: Improving equipment
Step 3: Improving processes

A. Process

a1. Differences due to External Factors

The principal products of both Mlecz and the excellent factory are powdered milk, ordinary milk, butter, and cheese, and there is no significant difference in the production volume and scale between them.

For both factories, the number of germs in the raw milk is 10^5 pcs/mL, thus showing no difference.

Table 5.5.8 shows an analysis of the powdered milk products made at the Mlecz plant, and again, there are no significant differences from the excellent factory.

The average annual temperature at the site of Mlecz is 6.4 °C, 1.9 °C lower than that of the excellent factory, at 8.3 °C. The heating of air for drying and the heating of the premises are thus affected by the temperature of the outside air. Air for drying is heated to 180 °C, and the steam used in the spray dryer accounts for 20 % of the total. As a result, the difference in steam used for heating is as follows.

134,400 GJ/y × 0.2 × 1.9/180 = 284 GJ/y
(fuel intensity: 284/0.7/21,000 = 0.019 GJ/t = 19 MJ/t)

The room heaters are set at 19° C, and the steam used for heating accounts for 35 % of the total; thus, the difference in steam for heating is as follows.
134,400 GJ/y × 0.35 × 1.9/19 = 4,704 GJ/y
(fuel consumption: 4,704/0.7/21,000 = 0.32 GJ/t = 320 MJ/t)
(where, the 0.7 in this case is the efficiency of the boilers)

The difference in fuel intensity due to external factors is as follows.
19 + 320=339 MJ/t

Table 5.5.8 Analysis of Powder Milk

	Fat	Low fat
Fat	26 % (normal)	Maximum 1.25 %
Proteins	26 %	35 %
Water	Maximum 4%	Maximum 4 %
No. of bacteria	Maximum 10,000/g	Maximum 10,000/g
(Standard in Poland	Maximum 50,000/g)	
Lactoze	38 %	51.75 %
Ash	5.9 – 6 %	8.0 %

a2. Differences Due to Technical Factors

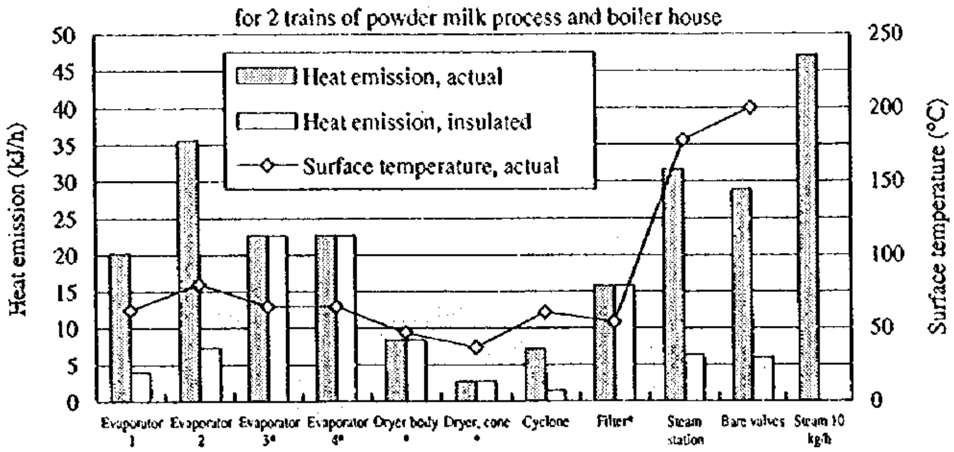
1) Hygiene Control

Various hygiene control measures are required. For example, a shallow disinfectant tank set into the floor should be installed at the entrances to the factory to allow the disinfecting of worker's rubber boots and prevent microorganisms from being introduced into the plant in that way. Positive air pressure should be maintained in the operations room to minimize the possibility of flying insects from entering the room and contaminating the products. Improved hygiene control would help to increase the number of the company's customers and allow it to boost production. It is believed that this, in turn, would improve the energy intensity.

b. Indoor Temperature Control and Heat Insulation

The city milk factory, which produces milk, butter, and cottage cheese, is kept at low temperatures, but the temperature in the powdered milk factory is high, at 30 ~ 40 °C, and many cases of heat radiation loss from equipment and pipes were observed. In particular, although heat-exchange equipment is installed at the top of the dryer, the steam pipes and valves are not insulated, and their exposure constitutes a danger factor, in addition to raising the temperature of the whole room. Moreover, while the surface temperature of the No. 4 evaporator, which is insulated, is 65 °C, the temperatures of No. 1, 2 and 3, which are not insulated, range from 80 °C to 84 °C. There is thus considerable heat loss by radiation and convection. These machines should therefore be insulated. Figure 5.5.9 shows the amount of heat loss from, and the surface temperatures of, the portions which require insulation. The 10 kg/h figures for steam shown at the right-side edge of the figure are for comparison of the respective heat-loss figures with steam volume.

Figure 5.5.9 Heat Emission & Surface Temperature



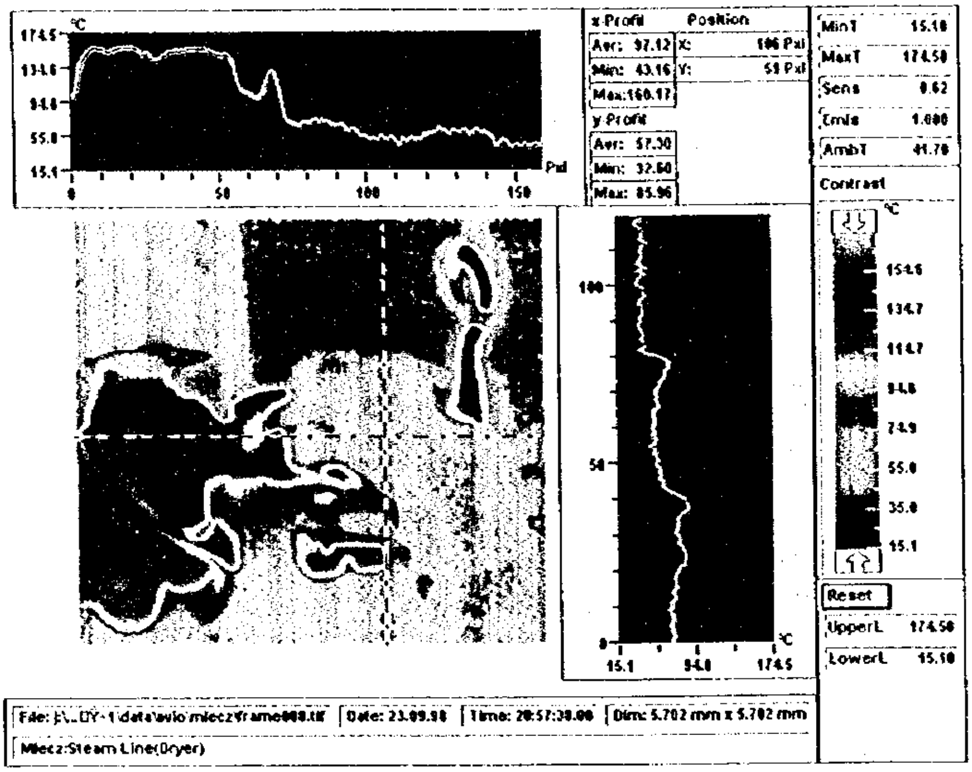
Facilities with symbol "*" have heat insulation already.

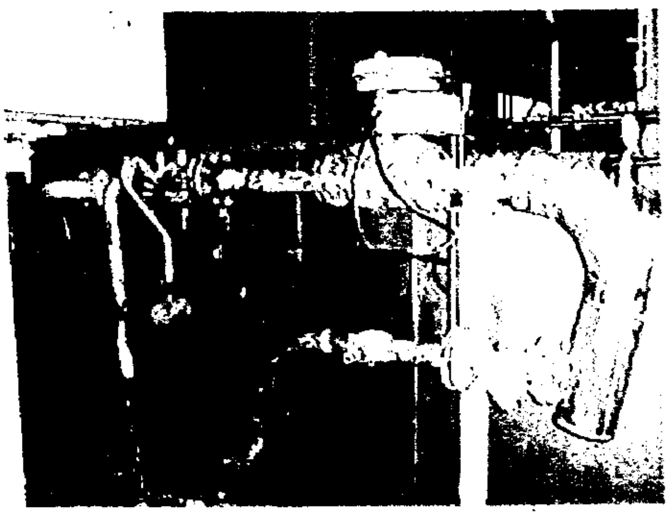
From Figure 5.5.9 we can estimate the amount of energy saving that would result from the use of insulation, as follows:

Two systems are shown for the evaporators.

Evaporator No. 1	: (20 – 4) MJ/h × 10 h/d × 365 d × 2 = 106,800 kJ/y
Evaporator No. 2	: (36 – 7) MJ/h × 10 h/d × 365 d × 2 = 211,700 kJ/y
Total	: 318,500 MJ/y
Fuel saving	: 318,500/0.7/1,000 = 455 GJ/y where, 0.7 is boiler efficiency.
Fuel intensity improvement	: 318,500/0.7/20,000 = 22.7 MJ/t
Steam valve at the top of the dryer:	(29 – 6) MJ/h × 10 h/d × 365 d = 83,956 kJ/y
Fuel saving	: 83,956/0.7/1,000 = 120 GJ/y

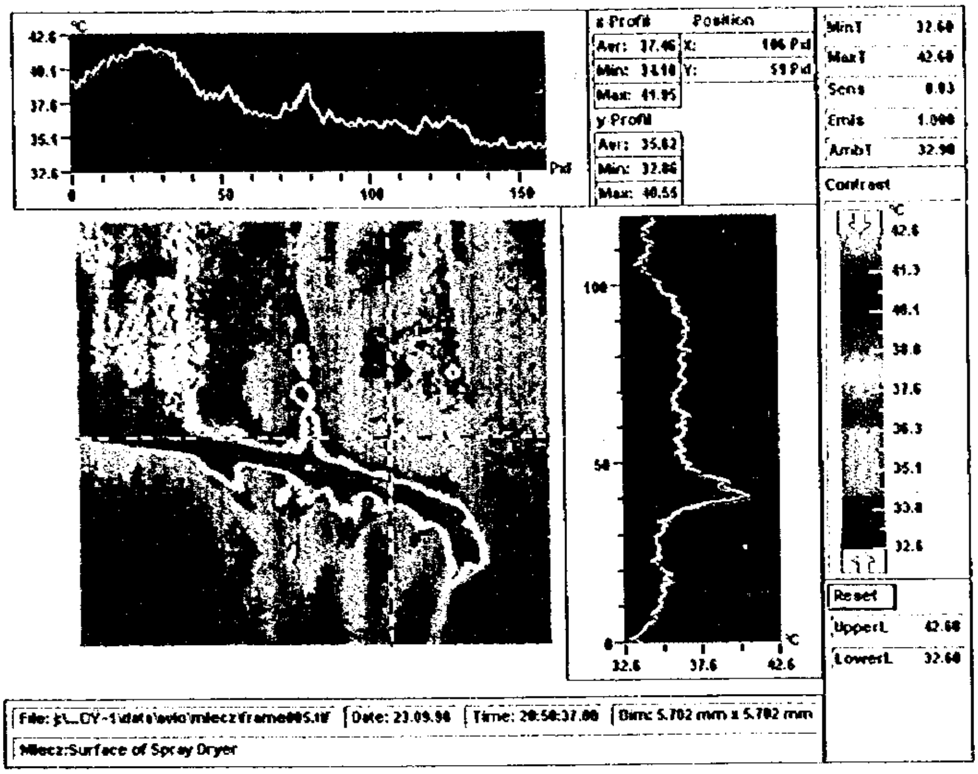
Figure 5.5.10 Thermal Image of the Spray Dryer Steam Valve

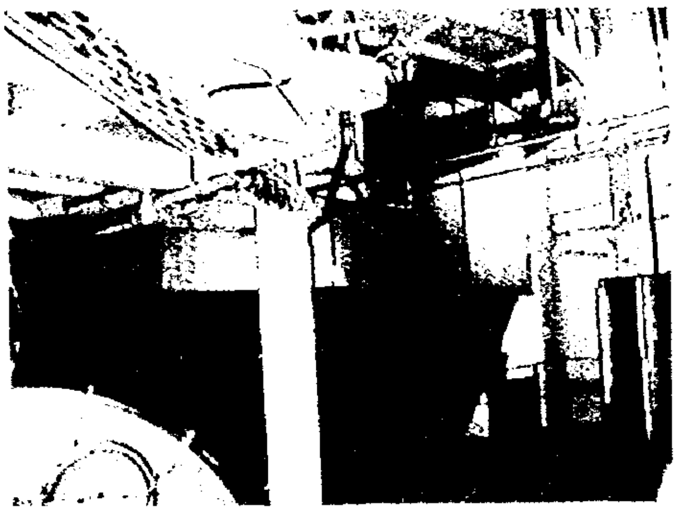




There is no insulation on the reducing valve and many other valves on the steam pipe used for heating the dryer air heater installed at the front of the powdered milk dryer. This thermal image is of the reducing valve, and shows that the surface temperature of the hottest part is 162 °C. By comparison, the temperature of the steam pipe, which is insulated, is only approximately 50 °C.

Figure 5.5.11 Thermal Image of the Spray Dryer Lower Part Edge





Although the dryer itself is insulated, the edge of the lower part, as shown in Figure 5.5.11, is at a high temperature. It is probably because this edge supports the weight of the whole dryer that it has not been wrapped with insulating material.

c. Evaporation and Drying of Powdered Milk

MLECZ processes 200 kL of raw milk per day, 20 % of which is destined for city milk product and 80 % for powdered milk. Powdered milk is divided into the full fat (26 % fat) and the low fat (1 % fat) types. The water content of the raw milk is 88 %, leaving 12 % in solids. In the evaporation process, the water content is reduced to 50 % in a quadruple evaporator, and then further reduced to 4 % by a spray dryer in the drying process to create powdered milk. If we calculate the material balance of the milk evaporation and drying processes from the analysis figures for the raw milk and the finished products, we obtain the values shown in Figure 5.5.12.

Figure 5.5.12 Material Balance in Evaporation and Drying Process

- Raw milk: 200 kL
  - City milk: 40 kL
  - Powder milk: 160 kL
    - Full fat powder milk (26 % fat): 80 kL
    - Low fat powder milk (1 % fat): 80 kL
      - Low fat powder milk: 72 kL
      - Butter and cheese: 8 kL

Material balance

kL = ton as the specific weight of raw milk is 1.0.

	Full fat powder milk			Low fat powder milk		
	Total	Water	Solid	Total	Water	Solid
1. Raw milk	80 t/d	70.4 t/d	9.6 t/d	72 t/d	63.4 t/d	8.6 t/d
(Solid content: 12 %)						
2. Evaporating process						
Output of evaporator	19.2 t/d	9.6 t/d	9.6 t/d	17.2 t/d	8.6 t/d	8.6 t/d
(Water content: 50 %)						
Evaporated water	60.8 t/d			54.8 t/d		
3. Drying process						
Output of dryer	10 t/d	0.4 t/d	9.6 t/d	8.9 t/d	0.3 t/d	8.9 t/d
(Water content: 4 %)						
Evaporated water	9.2 t/d			8.3 t/d		

From Figure 5.5.12, the volume of steam used in heating can be calculated from the volume of water evaporated during the evaporation and drying processes.

The latent heat of the steam used for heating is utilized in reducing the water content of the product in the evaporation process, and therefore the volume of heating steam must be equal to the volume of water evaporated.

As a quadruple evaporator is used in the evaporation process, theoretically, the volume of heating steam need be only 25 % of the volume of water content evaporated. Consequently, the volumes of heating steam are as follows:

Full fat powdered milk : 60.8 t/d × 0.25 = 15.2 t/d = 1.52 t/h (operation time: 10 h/d)
Low-fat powdered milk : 54.8 t/d × 0.25 = 13.7 t/d = 1.37 t/h (operation time: 10 h/d)

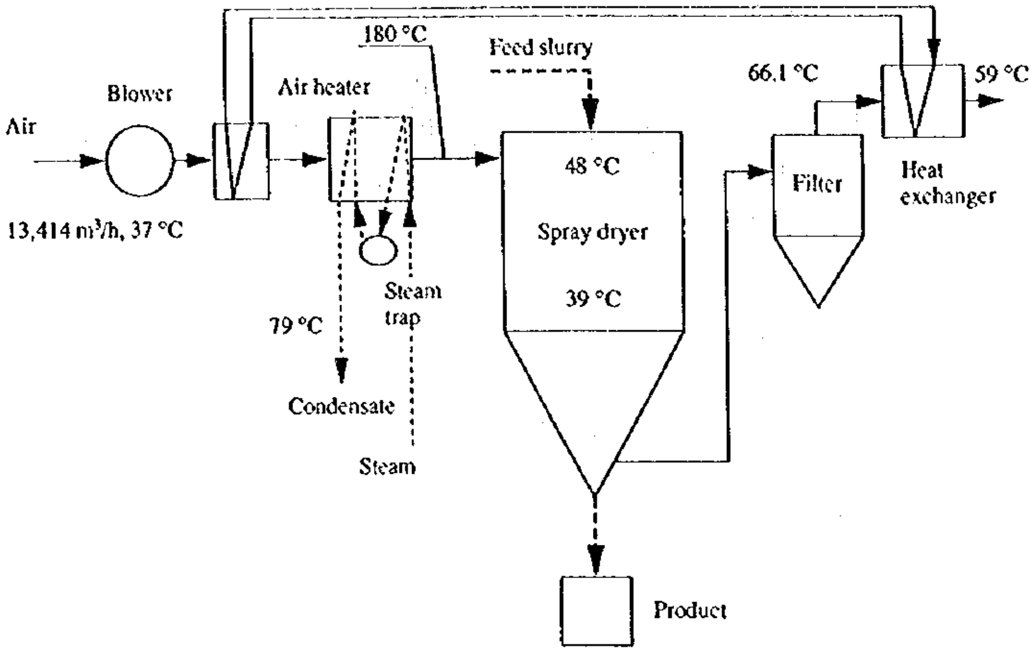
The figures for the drying process are as follows:

Full fat powdered milk : 9.2 t/d = 0.92 t/h (operation time: 10 h/d)
Low-fat powdered milk: 8.3 t/d = 0.83 t/h (operation time: 10 h/d)

As Figure 5.5.6 shows, the volume of steam used in one evaporator system at the Mlecz plant is 1.5 t/h, which is virtually identical to the figure calculated above. The volume of steam designed to be used in the spray dryer is 0.85 t/h, almost the same as the figure in our calculation. As Figure 5.5.6 shows, the volume of steam actually used during operations is 2.0 t/h, and the heat balance is thus calculated to be as follows:

		Category	Amount of heat (Mcal/h)	Remarks
1)	Heat input:	a. Steam heat	1,332.4	2 t/h, 1.4 MPa, 666.2 kcal/kg
		b. Heat retained in air	135.5	13,414 m^3/h, 37 °C
		c. Heat input total	1,467.9	
2)	Heat output:	d. Heat used in powdered milk drying	556.3	0.85 t/h
		e. Heat of condensate	158.0	79 °C, 2 t/h
		f. Heat loss from exhaust gas	216.0	heating air volume, 59 °C
		g. Amount of heat loss due to radiation	75.0	5 % of total heat input
		h. Others	387.6	heat from product cooling process, etc.
		i. Heat output total	1,467.9	

Figure 5.5.13 Measuring Point of Spray Dryer



Judging from the heat balance of the spray dryer, recovery of waste heat is being carried out sufficiently. All condensate is recovered and sent to the boiler room, but the temperature of the boiler room is approximately 40 °C. The condensate tank is located at the side of the powdered milk plant, and the company needs to use CIP cleaning and to improve the thermal insulation of the pipes that convey the condensate back to the boiler room.

The surface temperatures of the top portion of the main part of the dryer, the ceiling plates, and the hot air pipes are high, and improved thermal insulation is required.

If improved insulation sufficient to cut heat loss via radiation by 20 % is implemented, the amount of energy saved would be as follows.

75 Mcal × 4.1868 × 0.2 × 365 d/y × 10 h/d × 2 sets = 458,455 MJ/y
Fuel saving amount: 458,455/0.7/1,000 = 655 GJ/y
(Fuel intensity improvement: 655,000/20,000 = 32.7 MJ/t)

The Mlecz factory utilizes the HTST method of raw milk pasteurization, which means that the temperature is lower than in the UHT method used in the excellent factory and therefore the temperature of the milk supplied to the evaporator is also lower, requiring a greater amount of steam to be used in heating the evaporator. We have calculated the amount of steam used in a quadruple evaporator employing the steam ejector method.

Raw milk : 160 kL/d

Evaporator : Full fat powdered milk system, 80 kL/d; low fat powdered milk system, 80 kL/d

Amount of steam used in evaporator: 60.8 + 54.8 = 115.6 t/d

Amount of steam required for HTST-pasteurized milk

: as the evaporator is of the quadruple type, 115.6/4 = 28.9 t/d

Latent heat of steam : 28.9 × 500 kcal/kg = 14,450 Mcal/d

Difference in amount of heat retained by milk supplied to evaporator

: 160 t/d × 50 = 8,000 Mcal/d

Temperature difference between UHT (130 °C) and HTST (80 °C) is 50 °C
where, specific heat of milk is 1.0

Amount of steam required in the case of UHT-pasteurized milk

: 28.9 × (1 – 8,000/14,450) = 12.9 t/d

Difference in amount of steam : 28.9 – 12.9 = 16 t/d = 0.8 t/h (operation time: 20 h/d)

The HTST method is advisable in the case of city milk in order to maintain a high level of taste, but in the case of the pasteurization of milk for use in producing powdered milk, we advise conversion to the UHT method. Conversion to the UHT method would reduce the amount of steam required by the evaporator, and also, as explained below, reduce deposits on the inside surfaces of both the evaporator and the spray dryer, making possible continuous operation for 20 hours. The amount of reduction in steam at a pressure of 0.3MPa that this change in pasteurization method would effect is as follows:

16 t/d × 365 × 653 kcal/kg × 4.1868 kJ/cal/1,000 = 15,966 GJ/y
Fuel saving amount: 15,966/0.7 = 22,809 GJ/y
Fuel intensity improvement: 22,809/20,000 = 1.140 GJ/t = 1,140 MJ/t

Mlecz operates two evaporator and dryer systems alternately, with cleaning being carried out every 10 hours, but the excellent factory manufactures the same volume of products with only one system. Because the excellent factory operates the drying process for longer, it employs an antibacterial filter, through which the hot air is blown, and this system enables it to reduce the number of cleaning operations. As protein denaturing occurs within the evaporator, it has to be cleaned every 10 hours.

At the excellent factory, following pasteurization by the UHT method, pasteurized milk at a high temperature is transported to the No. 1 unit of the evaporator, and as little protein denaturing occurs within the evaporator, it can be operated continuously for 48 hours. The steam emitted from the No. 4 unit is used for reheating the No. 1 unit utilizing a heat pump. Consequently, hardly any steam is used by the evaporator. If the Mlecz factory were also to employ a system of hot air blown through antibacterial filters, each of the two systems in the drying process could be operated alternately for 10 hours at a stretch, and the factory could thus convert to 20 hours of continuous operation using one system. It is estimated that this method would achieve the following savings in energy.

Energy saving could be achieved using one system during the heating-up period and in the CIP cleaning process.

Energy used in heating-up phase: 667 kcal/kg (1.6 MPa steam) × 4 t/k × 0.5 h/time/ 4.186 = 318 MJ/time

If 1time/d,
318 × 365 = 116,070 MJ/y

The hot water used in CIP cleaning is the condensate recovered from the drying and evaporating processes, and therefore the heat rise is 30 °C

Energy of hot water used in CIP cleaning: 30 °C × 4,186 × 120,000 kg/time = 15,070 MJ/time

If 1time/d,
15,070 × 365 = 5,500,550 MJ/y
Total: 116,070 + 5,500,550 = 5,616,620 MJ/y
Fuel saving amount: 5,616,620/0.7/1,000 = 8,024 GJ/y
Fuel intensity improvement: 8,024,000/20,000 = 401 MJ/t
Water used in CIP cleaning is reduced by 120 t/d, reducing the load on waste water processing facilities.

d. Waste Water Treatment

The Mlecz factory produces a large amount of waste water, at 800 tonnes per day. Table 5.5.9 shows a comparison in percentage terms of the amounts of service (tap) water and waste water.

Table 5.5.9 Ratio of Service Water and Waste Water Amount

	Service water		Waste water		Waste water/Service water
	PLN	%	PLN	%	
City milk factory	203,173	54	367,455	57	1.80
Powder milk factory	88,977	24	170,205	27	1.13
Machine factory	26,272	7	4,359	1	0.14
Cooling	9,973	3	16,086	3	1.00
Boiler	42,909	12	71,655	11	0.92
Equipment	–		–		
Living expenses	–		9,595	1.5	–
Total	373,546	100	639,355	100	1.71

Remarks: The above data are based on the annual total for 1997. (800 t/d base)

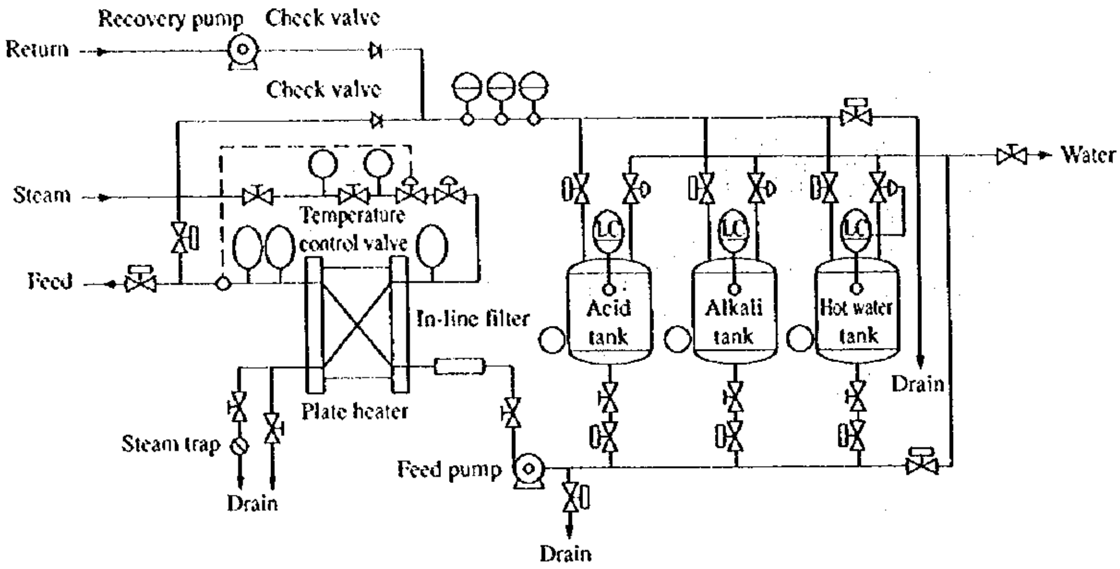
The city milk plant accounts for 56 % of the total waste water produced, while 26 % comes from the powdered milk plant. These two plants together account for 82 % of all the waste water produced by the Mlecz factory, or 656 tons per day. It is thus an urgent task for the company to take measures to use less water.

As a first step, the hose that is used to fill the floor tank should be fitted with a stopcock, which should be closed as soon as the tank is filled This improvement could save 3 % of total water volume used (656 t/d*0.03 = 20 t/d)
By means of the 20 hour-continuous operation of a single drying system explained above, the volume of water used in CIP cleaning could be reduced by 100 t/d.

Consequently, the total volume of 800 t/d of waste water could be reduced by 120 t/d.

Figure 5.5.14 shows the flowsheet of the CIP unit.

Figure 5.5.14 Flowsheet of CIP Unit



e. Improvement of Waste Water Treatment

Efforts are needed to reduce the phosphorous and nitrous compounds contained in the waste water. Reactions that remove nitrogen require an oxygen-free environment, the maximum permissible concentration of oxygen being 0.5 mg/L.

Recently, an improved version of the activated sludge process, a method that enables nitration and de-nitrification by alternating aerobic and anaerobic runs by means of intermittent aeration, was developed. With this method, the amount of dissolved oxygen required for BOD removal does not differ from that required in the conventional activated sludge process, and therefore it does not result in energy conservation. Since the decomposition rate of protein-containing waste water, such as milk waste water, is low in the activated sludge process, methods like the armature method and 3-floor spraying processes have also been tried. Generally, however, the lower cost oxiding pond process is implemented.

While 69 to 94 % of the required power is consumed on BOD processing of carbon sources, 6 to 31 % of the power is taken up for processing nitrogen.

While the oxiding pond method is adopted even at the excellent factory, energy conservation is attempted by holding the amount of power consumed by surface aeration. In its initial production design, MLECZ adopted an activated sludge method in which surface aeration is performed using stirring machine (22 kW × 7 units = 152 kW), to produce 200,000 kL/y, thereby showing an excessive amount of power consumption around the 70,000 kL/y output level.

As a first step in reducing this power, the stirring machines could be stopped one unit at a time, in accordancewith reductions in waste water treatment, while testing the waste water's BOD concentration.

If the stirring machines are stopped 1 unit at a time for a 140 t/d reduction in waste water as mentioned above, electric power intensity will become as follows.

When we investigated the factory, there were 6 stirring machines in operation, and power consumption was 142kWh. Therefore, when 1 stirring machine is stopped, 142 kWh/6 × 24 × 365 = 207,320 kWh/y of electric power will be saved.
(Reduction in electricity intensity: 207,320/20,000 = 10.4 kWh/t)

f. Cooling System (Improving the NH_3 freeze compressor)

The NH_3 refrigerator at the Mlecz Corporation is a very dated type, and its power consumption is twice that of the excellent factory.

Recently, NH_3 refrigerators are adopted throughout the world at an increasing pace. Accompanying restrictions on the use of freon, NH_3 is being viewed as an alternative cooling agent. The NH_3 refrigerator at the Mlecz Corp. is a 2 kW/uRT base model according to its name plate, while the excellent factory is using 0.9 kW/uRT base refrigerator. This is the result of high efficiency models with improved motor efficiency, and better compressor mechanisms, becoming widespread, as well as implementing conversions to these models. By adopting high efficiency models, substantial energy conservation was achieved. The electric power intensity at this factory in 1997 was 244 kWh/t-produced, with the power for the NH_3 compressor taking up 21.52 % in February, 26.6 % in August, with the average being 24 %.

244 × 0.24 = 58.6 kWh/t

Of this amount, when 2 units of NH_3 compressor 40 kW are replaced with a new 20 kW model, and a system is devised to strategically use the new model,
(Difference of 20 kW) × 24 × 365 × 2 = 350,400 kWh/y
(Reduction in electricity intensity: 350,400/20,000 = 17.5 Wh/y)

B. Heat Utilization Facility

b1. Technological factors

1) Boiler

There are 4 boilers installed at this factory. However, since one of them has a part removed, and cannot be operated, the actual facility consists of 3 units. The boiler facility and its operating state are shown in Table 5.5.10.

Table 5.5.10 Boiler Equipment and Operating Condition

Items	Contents		Remarks
No. of units	3		Installed
	2		Running
Model	OR-10-040		
Capacity, each	7.7	MW	MCR
	6.2	MW	ECR
Capacity, whole	23.1	MW	MCR
	18.6	MW	ECR
Steam generation	10	t/h-unit	Design
	3 to 5	t/h-unit	Actual working
Fuel	Coal		Stoker
Dust catcher	Multi-cyclone		
Air heater	Installed		After cyclone
			Tubler, gas for inside tube
Economizer	Not installed		
Draft	IDF/FDF		Balanced draft
Working status on panel readings			
Feed water temperature	140	°C	On drum inlet
Steam pressure	1.5	MPa	
Steam temperature	200	°C	
Steam generation	5.4 to 6.2	t/h	As total generation
High pressure steam	3.6	MPa	On steam collcrctor
	3.6	t/h	
Low pressure steam	1.5	MPa	On steam collector

Actual readings for measured data of September 24, 1998
MCR: Maximum Continuous Rating Capacity
ECR : Ecnomical Coutinuous Rating Capacity

Measuring and Analyzing Exhaust Gas

The temperatures of oxygen and gas, in the exhaust gas in the flue at boiler No. 1 while in operation, were measured and recorded. First, the measurement was conducted in the flue (after air preheater) outside the boiler room, then, a measurement of the flue (before air preheater, and after cyclone) inside the boiler room was added. Thus, the latter part of the graph has the measurement result before the air preheater added to it. The graph of the measurement values is shown in Figure 5.5.15, and the average, maximum, and minimum values of measurement are shown in Table 5.5.11. Additionally, since there is no change in oxygen concentration in the exhaust gas before or after the air preheater, according to the graph, it is estimated that there is no air leakage at the air preheater (in other words, no air leakage from the air side to the gas side). In this sense, air preheating is in a healthy state.

Figure 5.5.15 Exhaust Gas Oxygen & Temperature

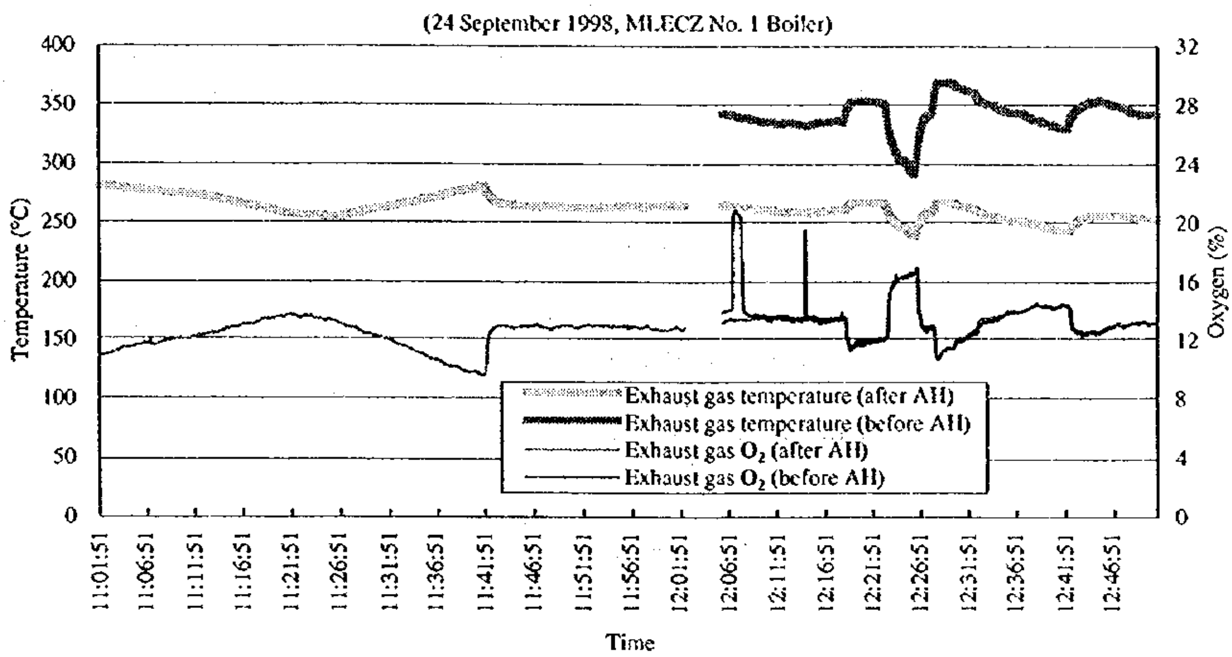


Table 5.5.11 Average, Maximum and Minimum of Measured Data

	After air heater		Before air heater	
	Temperature	Oxygen (%)	Temperature	Oxygen (%)
Average	265.9	12.5	341.9	13.5
Maximum	280.9	13.7	369.4	20.9
Minimum	254.0	9.6	391.1	10.7

① Improving the air ratio

When calculations are made assuming that the combustion air ratio has improved from the average to the minimum in the measured values, the results as shown in Table 5.5.12 will be obtained.

Table 5.5.12 Combustion Calculation before Air Heater

Premises	
Fuel gas	
Heat value Net (kJ/kg)	21,202
Heat value Net (kcal/kg)	5,064
Combustion air temperature	20
Exhaust temperature (before AH)	266
Exhaust temperature (aft assumed AH)	266
Air invasion into furnace	0.0 %

Rem: Measured at after AH

Results	Theoretical	AR actual	AR improved
Exhaust gas oxygen	0.0 %	12.5 %	9.6 %
Air ratio	1.00	2.44	1.82
Air volume (m^3/kg)	5.4	13.0	9.8
Exhaust gas (m^3/kg)	5.7	13.4	10.1
Exhaust gas heat loss (to fuel)		21.6 %	16.6 %
Fuel advantage			6.0 %

Rem: AR improved is minimum of measured values.
Exhaust gas loss is as of after AH

Thus, the air ratio is improved from 2.4 to 1.8, and consequently, fuel use drops by about 6 %. Additionally, the amount of exhaust gas is reduced from 13.4 m^3/kg to 10.1 m^3/kg, and exhaust gas heat loss drops from 21.6 % to 16.6 %.

When the combustion chamber was observed while the boiler was in operation, it seemed that air was being supplied even to the hearth where combustion had completed (the rear area of the hearth). This increased the amount of exhaust gas, and was thought to have been increasing heat loss due to the exhaust gas. Thus, it is necessary to keep the air ratio at a minimal level by improving combustion operations such as the damper and stoker speed of air supply.

Fuel saved by improving the air ratio is
6,250 t/y × 0.06 = 375 t/y
375 × 21.5 = 8,063 GJy
(Reduced fuel intensity: 8,063/20,000 = 0.403 GJ/t = 403 MJ/t)

② Cleaning the air preheater

The temperature of the preheated air was 110 °C when measured at the high temperature air's duct surface. On the other hand, in the thermal calculation for the boiler that was conducted in June 1996, the preheated air temperature was 170 °C. From this result, it can be said that the air preheater is currently no functioning adequately. If preheated air temperature is 170 °C as it was before, calculating from the heat balance of the air preheater, the temperature of the exhaust gas should become 205 °C, and there should be a 7 % reduction in fuel consumption due to a rise in preheated air temperature.

As reasons for the air preheater not to function, the heating surface may be contaminated with dust contained in the exhaust gas, or the heat exchanger tube may be blocked, and therefore, checks and repairs should be carried out.

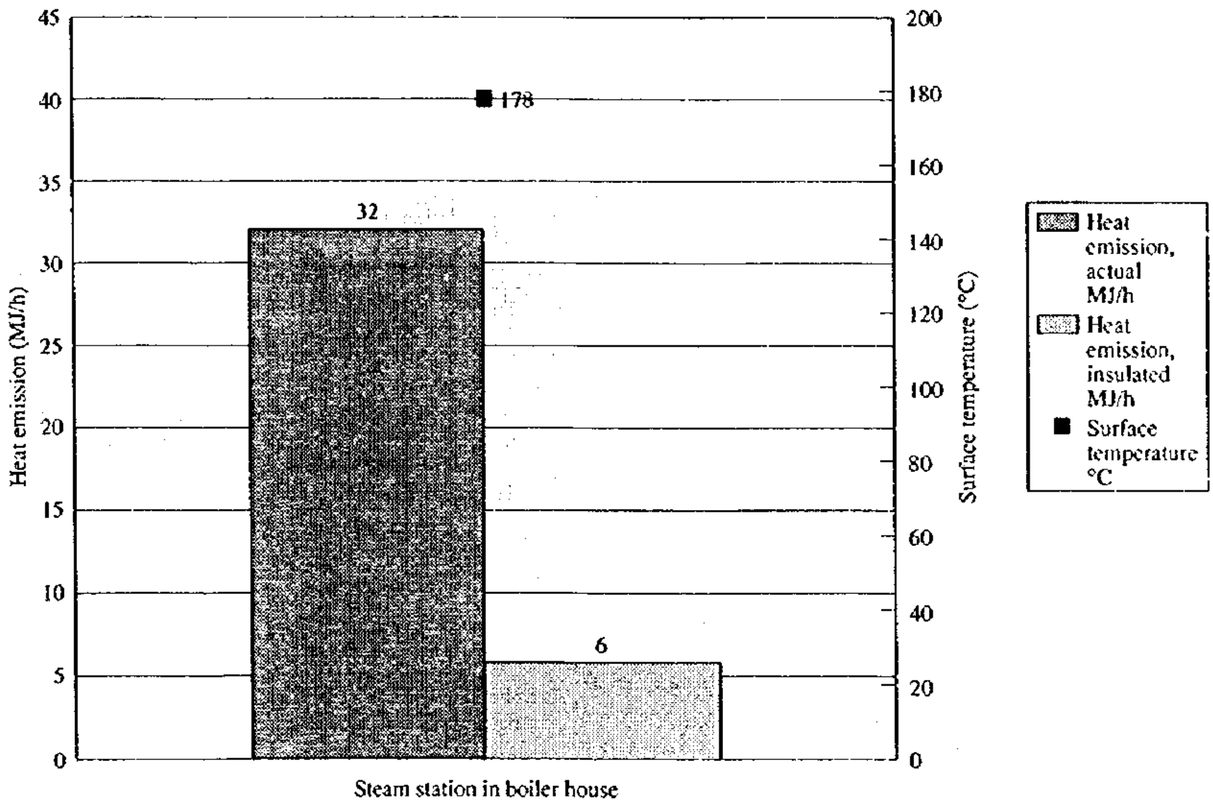
Amount of fuel saved due to rise in preheated air temperature (applying to No. 1 boiler)

6,250 t/y / 4 × 0.07 = 109 t/y
109 × 21,500 = 2,343,500 MJ/t
(Reduction in fuel intensity: 2,343,500/20,000 = 117 MJ/t)

2) Reinforcing heat insulation of steam valve

This factory has several facilities which are not insulated. Radiation heat from the surface of the boiler chamber's valve is calculated and shown in Figure 5.5.16. The amount of radiation heat was calculated from the measured value of the surface temperature. The surface temperature is also shown in the figure. Also shown in the figure is the amount of radiation heat from devices assuming that they are heat-insulated.

Figure 5.5.16 MLECZ Heat Emission in Boiler House



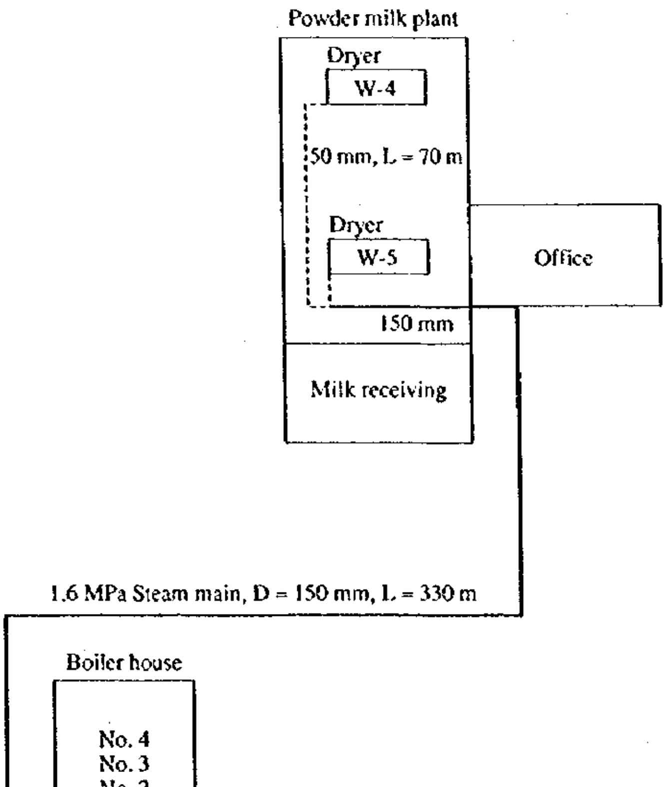
The amount of fuel saved by insulation
(32 – 7) MJ/h × 24 h/d × 365 d/y = 219,000 MJ/y
Fuel saving amount: 219,000/0.7/1,000 = 313 GJ/y
(Fuel intensity improvement: 313,000/20,000 = 15.6 MJ/t)

3) Pressure loss in the steam pipe

At this factory, a spray dryer is installed in its powder milk manufacturing process, where liquid milk is dried, and turned into powder milk. As the heat source for evaporating liquid, steam is used to heat air to about 200 °C, using a heat exchanger. According to the workers, due to shortages in the pressure level of the heating steam, there are times when the air temperature does not reach its required level.

In a 1.6 MPa pressure system, the heating steam goes outdoor from the boiler chamber via steam piping, entering the powder milk process, where it is divided, and sent into a 2-system dryer. The nominal diameter of the outdoor piping is 150 mm, while that of the indoor piping around the dryer is 50mm. The concept of the piping system is shown in Figure 5.5.17.

Figure 5.5.17 Steam Piping System



When the pressure loss for these steam pipes is calculated for the length of the piping, based on visual estimations made onsite, it becomes as shown in Figure 5.5.18 and Figure 5.5.19. Additionally, the calculation sheet is as shown in Table 5.5.17.

Figure 5.5.18 Steam Pipe Pressure Drop (D – 50 mm)

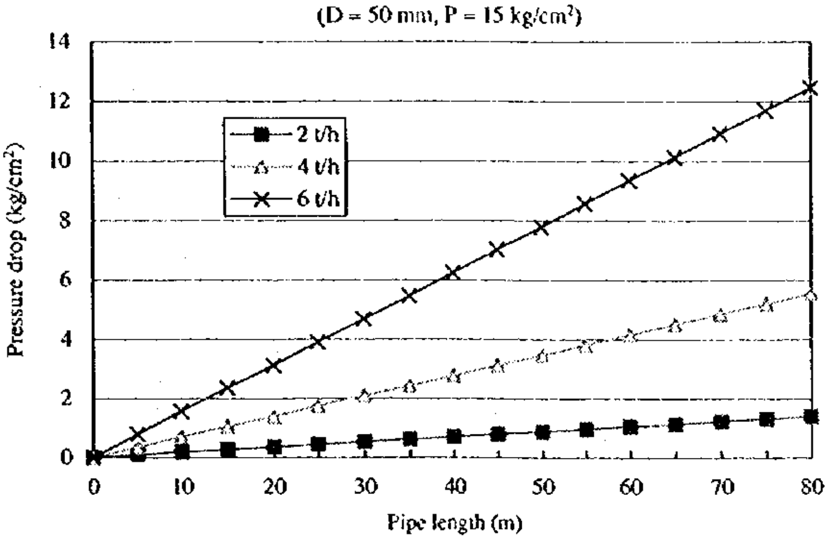


Figure 5.5.19 Steam Pipe Pressure Drop (D – 150 mm)

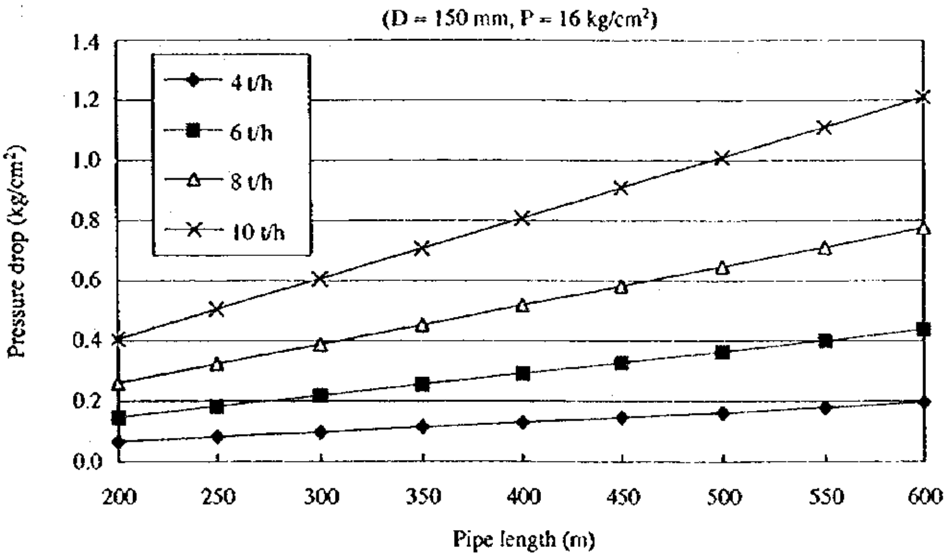


Table 5.5.13 Pressure Loss Calculation Sheet

Box	: set value

Applicable: 1.5 to 140 abs under
(Set nominal size A, then check nominal size B)

<Setting>

JIS pipe code		2
1: SGP 2: Sch40 3: Sch80		
Nominal size A (mm)		50
Nominal size B (inch)		2
Inside diameter: Di	m	0.0527
Pipe weight	kg/m	5.44
Steam flow: G	t/h	6
Pressure abs	kg/cm^2	15
Temperature	°C	197
Latent heat	kcal/kg	465
Unit vol:v	m^3/kg	0.1339
Sat temp	°C	197.4
Pipe length: L	m	80
Initial temperature	°C	20

<Calculated>			Saturated
Flow velocity	m/s		102.3
Pressure loss	kg/cm^2		12.464
Heat expansion	m		
		Carbon steel	0.160
		SUS 18-8	0.219
		Aluminum	0.322
		Copper	0.224
Heating steam	kg		18.4
(as saturated steam / steel pipe)			

If set temperature is less than saturation temperature of steam, the sheet assumes it as saturated steam.

Pressure loss formula: $10.5/10^8*v*G^2/((Di/1000)^5*(@PI/4)^2)/3.6^2*L$

As evident from these figures, the pressure loss for the outdoor 150 mm pipe is negligible, and thus, does not pose any problem. However, for the indoor 50 mm pipe, pressure loss does become a problem due to its steam flow rate. Especially for the W-4 dryer, since its steam pipe length (taking into account the extensive length of its bent part) is about 70 m, which means if steam flow rate is 2.5 t/h, pressure loss becomes 2 kg/cm^2. The reduction in steam saturated temperature equivalent to this pressure loss is about 5 °C.

Steam consumption according to the planning documents the factory owns, is supposed to be 5 t/h. Also, the flow rate calculated by the JICA team, based on the draft measurement of the dryer's blower, became 0.6 t/h. When taking into consideration the fluctuation in steam quantity due to fluctuations in the operation, there are probably times when the pressure loss in this 50 mm steam pipe hinders the dryer's operation, thus, not only would it be advisable to pay close attention to the steam pressure at the inlet of the heat exchanger in the future, but the 50 mm piping may also have to be replaced with a larger diameter.

C. Electric Facility

c1. Technological factors

1) Electricity conservation for the compressor

Data on load measurements for principal electric equipment at this factory are shown in Table 5.5.14.

Table 5.5.14 Measurement Data of Major Load

Transformer	Name of load	Rating (kW)	Consumption (kWh)	Voltage (V)	P.F	Remark
	Receiving power	1,450 (1,250)	640 ~ 1,380	15,000		September 1998
NR1	(14-2 Dry milk)		247 ~ 346	400	99	cont.
	Fan of spray drier	2 × 22	23	400	92	
	Water pump	35	30	400	94	
	Agitator		35	401	95	
	Ventilator fan	2 × 75	104	400	77	
	Refrigerator		49	401	93	
NR2	(14-1 cheese department)		35 ~ 206			cont.
	Air compressor	37	10	400	27	
	Centrifugal oil separator	2 × 35	39	400	94	1 operate
	Refrigerator	2.2 × 10	21	402	84	
	Extruder		71	401	98	
	Packing of milk		14	403	86	
NR8	(13 Energy)		~ 590		91	cont.
	Water pump (city water)	4 × 30	10	405	23	light load
	NH3 compressor	3 × 55	39	405	74	
	NH3 compressor	2 × 37	26	405	65	
	Air compressor	2 × 75	64 (10)	393	81 (27)	( ) un-load
NR14	(Boiler)	3 ×	139	383	88	2 operate
	Fan of combution air	3 × 18.5	11	379	84	
	Water pump	3 × 22	11	379	83	intermit.
	Exhaust fan	3 × 55	99	381	86	2 operate
NR15a	(15 Sewage works)		200	402		
	Agitator for aeration	7 × 22	142	402	76	6 operate
	Pump of waste water	30	30	402	85*	*: guess

Note: intermit.: operation is intermittent, cont: continuous measurement

This factory has a 75 kW and a 37 kW air compressor at the energy plant and the cheese factory, respectively. The loads, when measured, were 64 kWh/10 kWh and 10 kWh. Because the former has an excessive capacity, it continues to make ON-OFF operations once every minute (28 % of actual full capacity). Under this condition, peak power when starting is large, and the control circuit is susceptible to damage. As a countermeasure, the two air piping can be consolidated, to stop the machinery at the energy plant. However, the air tank will be used. If capacity is lacking by 37 kW, about 15 kW of facility will be additionally installed.

With the improvement, peak power for the 75 kW machine disappears, control circuit failures disappear, and the following amount of energy conservation can be expected.

Load in the current state will be
$((64 + 10)/2 + 10) \times 24\ h \times 365 = 411{,}720$ kWh/y

Load after modification will be
$(37 + 10) \times 0.5 \times 24 \times 365 = 205{,}800$ kWh/y

Therefore, the amount of power saved will be 205,800 kWh/y.
(Reduction in electricity intensity: 205,800/20,000 = 10.3 kWh/y)

2) Energy conservation for the boiler's motor

The load on the boiler constantly changes with the state of its use. Although fans, ventilators, and pumps are generally automatically adjusted by dampers and valves, they are manually adjusted at this factory, which tends to waste electricity. In such case, automatically controlling the number of rotations of the motor, depending on the flow rate of the fuel and water, will reduce the amount of power that goes to waste. As evident from Table 5.5.14, the 4 fans for the boiler at this factory uses 110 kW, and the fan for combustion air is only taking a light load. Controlling these with an inverter, and operating at 80 % load 24 hours a day (others are run at full capacity), is believed to result in an approximately 44 kW saving in power.

The amount of power saved is
44 kWh × 24 h/d × 365 d/y = 385,440 kWh/y
(Reduction in electricity intensity: 385,440/20,000 = 19.3 kWh/t)

3) Power conservation for transformer

The transformers at this factory had currents of 200 A running through them even when they had no current load (0). The condensers need to be OFF. If there is no load, turning OFF the transformers will reduce the power loss from the transformers, and therefore, they should be managed with care.

4) Energy conservation for lighting

Lighting is actively turned off during the daytime at this factory, which is a good practice in terms of energy conservation. The power for the electric lamps installed at the factory is believed to be about 120 kW indoor, and about 15 kW (60 × 250 W depending on the factory) outdoors. Of these, most indoor lamps are fluorescent lamps, and their mounting height is about 6 m, which is too high. Illuminance was about 200 to 300 lux when the lights were on. The following should be considered to save power in such case.

① Lower the height of the indoor lighting from the current 6 m to about 4 m. However, where this measure would hinder work, they should be exchanged to mercury lamps. If this is implemented, even if the same level of illuminance is maintained, the amount of power required will be reduced to a half, saving about 92,000 kWh (1.8 % of total) annually.

120 kW × 0.7 0.5 × 1/2 × 12 m × 365d = 92,000 kWh
where 0.7: rate of use, 0.5: rate of implementation of measure

② In case of outdoor lighting, they should be replaced with sodium lamps. The effect of this will be about 40 % in power saved, and a reduction of 17,520 kWh (0.2 % of total) annually.

15 kW × 0.4 × 0.8 × 10 h × 365 d = 17,520 kWh
(reduction in electricity intensity: (92,000 + 17,520)/20,000 = 5.5 kW/t)

D. Co-generation

After implementing energy conservation to processes, a measure that deserves a great amount of attention as natural gas becomes usable in the future is co-generation. Natural gas is planned to be supplied to this region in the year 2001.

While seasonal fluctuations exist for heat and power demand in MLECZ, the demand for heat is great. Although demand for steam does not change much between night and day, the fact that power demand at night is less than 50 % of daytime poses a problem upon adopting co-generation. Ways to make the load even between day and night should be studied.

The basic specification for co-generation is as follows.
Generator output : 400 kW
High pressure steam: 2 t/h, 1.6 MPa
Low pressure steam : 7 t/h, 0.3 MPa

A system flow for a back pressure steam turbine type co-generation system is shown in Figure 5.5.20.

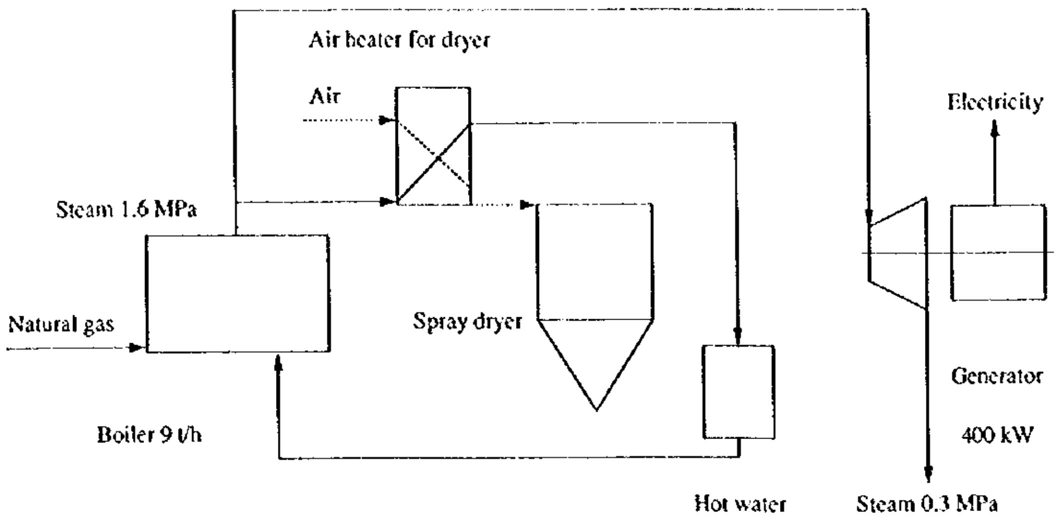
The results of comparing natural gas cogeneration system with the conventional system are as shown below.

Item	Conventional system	Cogeneration system
1. Equipment		
1) Boiler	Coal-fired boiler	Natural gas boiler
2) Dust collector and exhaust gas desulfurizer	Newly installed	Not required
3) Electricity	Purchased	In-house power generation + purchased power
2. Fuel		
1) Coal	113,400 GJ/y (810,000 PLN/y)	
2) Natural gas		94,915 GJ/y (1,336,611 PLN/y)
3) Emission fee for environmental protection	29,712 PLN/y	6,083 PLN/y
3. Electricity		
1) Purchased power	5,544 MWh/y (953,568 PLN/y)	2,075 MWh/y (356,900 PLN/y)
2) In-house power generation	0	3,469 MWh/y
3) Electric power (purchased) for exhaust gas desulfurizer	1,800 MWh/y (309,600 PLN/y)	0
4. Total cost	2,102,880 PLN/y	1,699,594 PLN/y
(Difference)		(403,286 PLN/y)
5. Investment amount	1,000,000 PLN/y	4,000,000 PLN/y
(Difference)		(3,000,000 PLN/y)
6. Simple payback period		7.4 year

The payback period for natural gas cogeneration system is 7.4 years, and thus the introduction of this system is at present not economically viable. One factor contributing to this is that coal is cheaper than natural gas.

Yet, by adopting co-generation, exhaust of CO_2 is reduced by over 40 %, and environmental protection emission fees are reduced by 80 % or more.
It is thus recommended that due consideration be given to the shorteneing of the payback period by effective use of environmental improvement incentives by means of environmental protection funds.

Figure 5.5.20 Co-generation System Flow



(3) Summary of Energy Conservation Potential

a. Improvement of Environment through Energy Conservation

If fuel consumption is reduced through energy conservation, the quantity of pollutants emitted to the atmosphere also decreases. Additionally, if the amount of purchased power is reduced through energy conservation, so is the amount of power generated, that is, the quantity of pollutants emitted to the atmosphere by power plants. This reduction in emission quantity due to energy conservation depends not only on the amount of energy conservation, but also the type of fuel, and equipment, such as boilers, etc. Therefore the correct way to estimate the quantity of pollutants is to use the actual amount emitted by each factory. Here, however, for the sake of the consistency with the comprehensive study on Poland as a whole, calculations are based on information on the unit emission quantity (pollutant tonnage/fuel-heating value TJ), per industrial sector and per fuel type, provided by a document from the Institute of Environmental Protection. The reduction in the emission of air pollutants from this factory achieved as a result of energy conservation is compiled at each stage of energy conservation, and shown in Table 5.5.15.

Table 5.5.15 Emission Improvement by Energy Conservation Measures

Measure	Reduction [ton/year]			
	CO_2	SO_2	NO_2	Dust
Step 0				
Step 1	997	7.0	1.9	1.5
Step 2	3,051	21.5	5.7	4.6
Step 3	5,485	75.6	14.9	16.2
Step 1-3	9,533	104.2	22.5	22.3

Reduction includes emission from fuel and electricity.

Also, in Poland, there is a system available that charges an emission fee (fee) to the polluter, and thus, the emission fee can be reduced through energy conservation. The unit price of the fee is specified per pollutant type. Additionally, for emissions that exceed a certain amount, a penalty fee (charge) is charged. The unit price of the charge is 100 times that of the fee. The prices listed below are the regular emission fees.

The result of calculating the amounts of reduction in pollutant emission, for the energy conservation items that were proposed based on our factory survey, and the corresponding reductions in emission fees, is shown in Table 5.5.16. Furthermore, the payback required to recover energy conservation investments including the effect of reduced emission fees, and the payback period based only on fuel reductions, are listed together in this table.

Table 5.5.16 Payback Period Improvement by Emission Fee Reduction

Measures	Energy cost advantage	Emission fee advantage	Total advantage	Investment	Eco-Environ. PBP	Economical PBP
Step 0						
Step 1	147	3.1	150	0	0.00	0.00
Step 2	379	9.5	388	1,699	4.38	4.49
Step 3	379	31.2	410	3,000	7.31	7.91
Step 1-3	905	43.9	949	4,699	4.95	5.19

Units: Thousand PLN or thousand PLN/y for expense, Year for PBP

As evident from this Table 5.5.16, the reduction in emission fee is only a few percents at most compared to reduction in energy cost, and thus, the effect of reduced emission fees on the investment recovery period is also negligible.

The improvement items for this factory involve fuel (coal) and electricity, each of which accounts for 50 % in Step 1. The ratio of the reduction in the emission fee to the reduction in energy cost is 20 % in Step 1. In Step 2, the improvement of electricity is larger than that of fuel, and therefore the ratio is 1.5 %. This is because the emission fee for coal is larger than that for coal.

b. Summary of Energy Conservation Potential

The energy conservation potential of this factory is shown in Table 5.5.17.

The energy conservation potential using the Excellent factory as the benchmark for energy consumption intensity, and energy conservation measures in Steps 1, 2, and 3 are shown in Figure 5.7.21. The relationship between energy conservation potential, the payback period, and the investment cost is shown in Figure 5.5.22.

Table 5.5.17 Summary of Energy Conservation Potential

Coal: 170 PLN/t (23.8 GJ/t) Electricity: 0.172 PLN/kWh 1 PLN = 30 yen

Item	Energy Conservation Potential: Fuel GJ/y	Fuel 10^3 PLN/y	Fuel %	Electricity MWh/y	Electricity 10^3 PLN/y	Electricity %	Total 10^3 PLN/y	Investment 10^3 PLN	Payback period year
Step 1									
1. Restoring the heat insulation of the dryer steam piping	120	1	0				1	0	0.0
2. Stopping one stirrer for waste water treatment		0	0	207	36	2	36	0	0.0
3. Improving the boiler air ratio	8,063	58	6		0	0	58	0	0.0
4. Installing an air preheater for boilers	2,343	17	2		0	0	17	0	0.0
5. Connecting air compressors		0	0	206	35	2	35	0	0.0
6. Cutting out an unloaded transformer				1	0	0	0	0	0.0
Subtotal	10,526	76	8	413	71	8	147	0	0.0
Step 2									
7. Reinforcing the heat insulation of the evaporators	455	3	0		0	0	3	30	9.1
8. Reinforcing the heat insulation of the dryer proper	655	5	0		0	0	5	30	6.3
9. Adopting UHT for the pasteurization system	22,809	165	17		0	0	165	1,000	6.1
10. Operating a 1 system for dryers	8,024	58	6		0	0	58	200	3.4
11. Improving the cooling system		0	0	350	60	4	60	200	3.3
12. Reinforcing the heat insulation of steam valves in the boiler room	313	2	0		0	0	2	10	4.4
13. Controlling the boiler motors by inverter		0	0	355	66	5	66	189	2.9
14. Improving the room lighting		0	0	92	16	1	16	10	0.6
15. Changing the outdoor lighting system to sodium lamps		0	0	17	3	0	3	30	10.3
Subtotal	32,256	233	24	844	145	17	379	1,699	4.5
Step 3									
16. Natural gas cogeneration	18,485	Δ527	14	5,269	906	62	379	3,000	7.9
Subtotal	18,485	Δ527	14	5,269	906	62	379	3,000	7.9
Total	61,267	Δ218	46	6,526	1,122	87	905	4,699	5.2

As of 1997: Production volume: 20,000 t/y
Fuel consumption: 134,399 GJ/y
Electricity consumption: 5,085 MWh/y (diary factory)
Electricity consumption : 6,680 MWh/y (including waste water treatment facilities)
Electricity consumption : 8,480 MWh/y (including waste water treatment facilities and exhaust gas desulfurizer)

Figure 5.5.21 MLECZ Energy Conservation Potetial

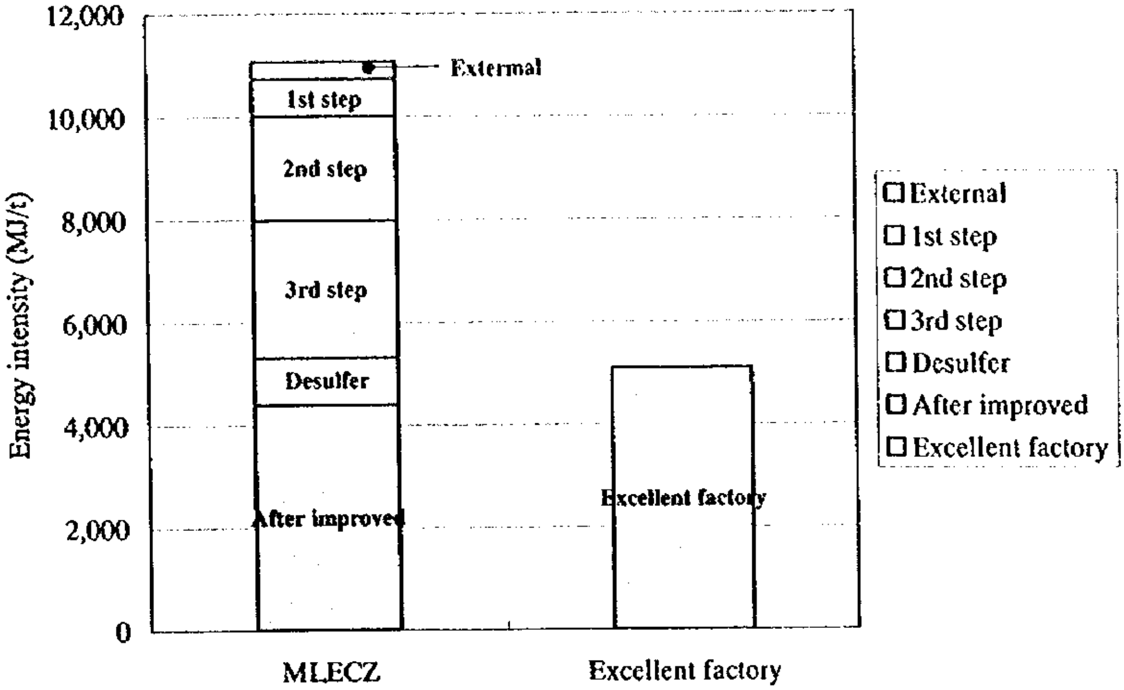
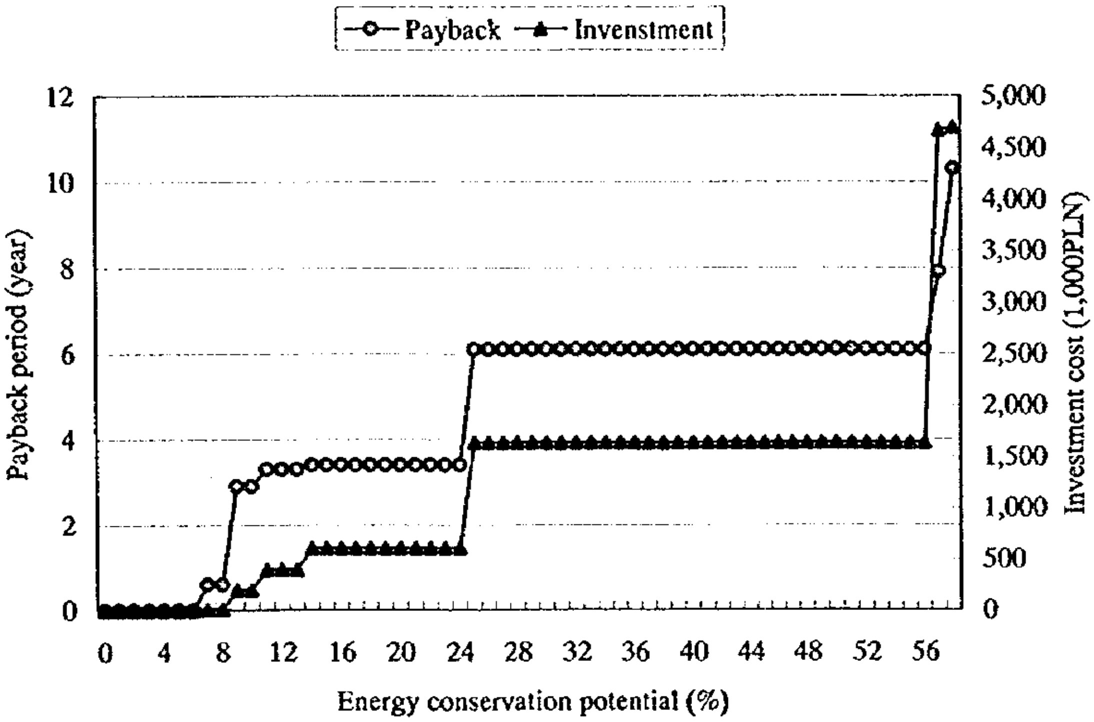


Figure 5.5.22 MLECZ Energy Conservation Potetial



6. CURRENT SITUATION OF ENERGY CONSUMPTION BY ENERGY UTILIZATION FACILITIES

6. CURRENT SITUATION OF ENERGY CONSUMPTION BY ENERGY UTILIZATION EQUIPMENT

During our 15 factory energy audit in Poland, we surveyed the actual status of energy use in the following types of energy consumption equipment as well as energy conservation potential.

- Lighting equipment
- Air compressor
- Motor
- Transformer
- Factory space heating
- Boiler
- Heating furnace

6.1 Lighting Equipment

The energy conservation potential of lighting in each factory is 27.7 % as shown in Table 6.1. For indoor lighting in factories, mainly fluorescent lamps and mercury lamps are installed, while mercury lamps are provided outdoors.

Recommendable energy conservation measures for lighting are as follows:

(1) Replace fluorescent lamps with high-frequency fluorescent lamps.

This measure allows power consumption to be reduced by approximately 40 %.

(2) Replace mercury lamps with high-pressure sodium lamps.

The sodium lamps can be used in a place where no problem occurs in terms of color rendering property, thus allowing an approximately 40 % power saving.

(3) Lower the height of lighting apparatuses.

The illuminance is in inverse proportion to the square of the distance and therefore, for example, lowering a lamp from the height of 6 m above the floor to 4 m can bring about a 50 % energy conservation effect.

Although replacement of existing lighting appliances with high-efficiency ones leads to about 20 % energy conservation as shown in Table 6.1, the payback period is within the range of 5 years to 15 years, which is long. The payback period for outdoor lamps which are lit for 8 to 12 hours per day is especially long. Hence it is advisable to replace current lamps and lighting fixtures with high-efficiency ones, when lamps break or deteriorate.

In most of the factories surveyed, lighting is turned off during daytime according to the instruction by the administrator. In some factories, outdoor lamps are left on during the daytime, while in other factories indoor lamps are lit at a place where a sufficient illuminance is obtained by the natural light through the window. Employees should be trained and educated so as to raise awareness regarding such matter. As another method, equipment may be improved to allow an automatic turning on/off control by means of a timer or sensor.

In some workplaces on the other hand, turning-off of lighting was so thoroughly implemented as to make it difficult for people to walk in the passage, while in other workplaces, illuminance criteria were not satisfied. It is necessary to implement the turning on/off of lights according to the illuminance standards in Poland. Maintenance is equally important, including the periodical cleaning of luminaires instead of leaving them dusty, cleaning the skylight, etc.

Table 6.1 Energy Conservation Potential of Lighting Equipment

Electricity: 0.172 PLN/kWh 1 PLN = 35 yen

Item			Energy conservation potential Electricity [MWh/y]	[1,000 PLN/y]	Investment cost [1,000 PLN]	Payback period [year]
1st step						
1	Steel	Turning off unnecessary lamps	7	1	0	0.0
2	Machine	Lower fluorescent lamps to 4 m	2	0.3	0	0.0
3	Chemical	Turning off unnecessary lamps	29	5	0	0.0
Subtotal			38	6	0	0.0
2nd step						
4	Steel	Change mercury lamp to sodium lamp	736	127	857	6.8
5	Steel	Change mercury lamp to sodium lamp	3,360	578	1,971	3.4
6	Chemical	Change mercury lamp to sodium lamp	210	36	34	0.9
7	Chemical	Change mercury lamp to sodium lamp	82	14	217	15.4
8	Machine	Change mercury lamp to sodium lamp	108	19	140	7.5
9	Machine	Change fluorescent lamp to high frequency lar	77	13	252	19.0
10	Machine	Change to high efficiency lamp	616	106	1,500	14.2
11	Glass	Change mercury lamp to sodium lamp (Outside)	135	23	47	2.0
12	Non-metallic	Change mercury lamp to sodium lamp (Outside)	4	1	9	13.1
13	Food	Change mercury lamp to sodium lamp (Outside)	9	2	15	9.7
14	Food	Improvement of lighting in building	92	16	10	0.6
15	Food	Change mercury lamp to sodium lamp (Outside)	17	3	30	10.3
Subtotal			5,446	937	5,082	5.4
3rd step						
Subtotal						
Total (1st, 2nd and 3rd steps)			5,484	943	5,082	5.4

No.	Factory	Factory: Heat consumption (A) [GJ/y]	Electricity consumption (B) [MWh/y]	Elctricity consumption (C) [GJ/y]	Energy consumption (D) = (A) + (C) [GJ/y]	Lighting equipment: Installed capacity [kW]	Energy consumption (E) [MWh/y]	Ratio (E)/(B) [%]	Energy conservation potential of equipment (F) [MWh/y]	(F)/(E) [%]
1	Labedy	679,979	36,940	378,931	1,058,910	300	2,628	7.1	736	28.0
2	Ostrowiec	3,419,092	626,637	6,428,042	9,847,134	1,200	10,512	1.7	3,360	32.0
3	Lacznikow	261,988	27,963	286,844	548,832	20	34	0.1	7	20.6
4	Blachownia	807,953	6,591	67,610	875,563	150	657	10.0	210	32.0
5	Poch	321,185	4,941	50,685	371,870	70	204	4.1	82	40.2
6	Boruta	70,950	2,024	20,762	91,712	20	175	8.6	29	16.6
7	Ursus	860,645	114,087	1,170,304	2,030,949	1,000	4,000	3.5	801	20.0
9	Wolomin	792,661	19,380	198,800	991,461	240	744	3.8	135	18.1
10	Silikaty	75,711	663	6,801	82,512	4	11	1.7	4	36.4
12	Koscian	50,083	2,650	27,184	77,267	5	21	0.8	9	42.9
15	MLECZ	134,399	5,085	52,162	186,561	135	791	15.6	109	13.8
Total		7,474,646	846,961	8,688,126	16,162,772	3,144	19,777	2.3	5,482	27.7

Energy consumption ratio of equipment in factories: 10.258* (E)/(D) = 1.3 %

6.2 Air Compressor

Energy conservation potential of air compressors in each factory is 35.9 % as shown in Table 6.2.

The types of compressors in use include reciprocating compressors and large-size turbo compressors (1,000 kW to 2,000 kW).

Following are energy conservation measures recommended.

(1) Flow rate control of turbo compressors by suction vanes

For turbo compressors for which variable speed control is not available for controlling the flow rate, electricity consumption can be reduced by 10 % through flow rate control using suction vanes.

(2) Lower the discharge air pressure of a compressor.

The discharge air pressure should be decreased as much as possible depending on the air pressure required by the factory.

Reducing the pressure by 0.1 MPa will achieve a 6 % power saving.

(3) Change the arrangement of compressors from the centralization system to the decentralization system.

When the consumption of compressed air is fixed, use of the centralized arrangement of large-size compressors is advantageous. On the other hand, when there is a large fluctuation in load, the decentralized arrangement of small-size compressors is preferable.

(4) Adoption of a screw compressor

In upgrading turbo compressors, in order to cope with a large load fluctuation, it is advisable to use a screw compressor which allows the flow rate to be controlled through variable speed drive.

(5) Control the number of operating units to cope with a load fluctuation.

It is recommended that the current method of accommodating load variations, that is, by means of releasing the excess air into the atmosphere, should be switched to the compressor ON/OFF system for controlling the number of operating units or to the small reciprocating compressor unload operation system.

(6) Countermeasures for air leakage

In all of the surveyed factories, there was observed a large amount of air leakage. Air leak check must be conducted on factory shutdown days to prevent the occurrence of air leak as much as possible.

As shown in Table 6.2, energy conservation measures for air compressors are feasible because of a shorter payback period, which is within 4 years.

Table 6.2 Energy Conservation Potential of Air Compressor

Electricity: 0.172 PLN/kWh 1 PLN = 35 yen

Item			Energy conservation potential Electricity [MWh/y]	[1,000 PLN/y]	Investment cost [1,000 PLN]	Payback period [year]
1st step						
1	Steel	Improvement of operation system	296	51	57	1.1
2	Steel	Reduction of air leakage	343	128	0	0.0
3	Machine	Reduction of air leakage	4,800	826	0	0.0
4	Glass	Reduction of pressure	1,505	259	0	0.0
5	Food	Connection of compressor	206	35	0	0.0
Subtotal			7,550	1,299	57	0.0
2nd step						
6	Steel	Installation of small compressor	365	63	250	4.0
7	Steel	Improvement of pressure control of turbo	772	133	286	2.2
8	Chemical	Installation of small compressor in each shop	880	151	250	1.7
9	Machine	Reduction of pressure	1,170	201	43	0.2
10	Machine	Reduction of pressure	140	24	20	0.8
11	Machine	Installation of small compressor	3,832	659	130	0.2
12	Machine	Improvement of compressor	600	103	143	1.4
Subtotal			7,759	1,335	1,122	0.8
3rd step						
Subtotal						
Total (1st, 2nd and 3rd steps)			15,309	2,633	1,179	0.4

No.	Factory	Factory: Heat consumption (A) [GJ/y]	Electricity consumption (B) [MWh/y]	Elctricity consumption (C) [GJ/y]	Energy consumption (D) = (A) + (C) [GJ/y]	Air compressor: Installed capacity [kW*Set]	Energy consumption (E) [MWh/y]	Ratio (E)/(B) [%]	Energy conservation potential of equipment (F) [MWh/y]	(F)/(E) [%]
1	Labedy	379,979	36,940	378,931	1,058,910	350 kW*3	5,830	15.8	772	13.2
3	Lacznikow	261,988	27,963	286,844	548,832	200 kW*7	2,343	8.4	1,404	59.9
6	Boruta	70,950	2,024	20,762	91,712	1,000 kW*1	1,600	79.1	880	55.0
7	Ursus	860,645	114,087	1,170,304	2,030,979	1,910 kW*9	24,000	21.0	9,802	40.8
8	Star	466,821	23,573	241,812	708,633	1,800 kW*1	2,800	11.9	740	26.4
9	Wolomin	792,661	19,380	198,800	991,461	200 kW*5	5,160	26.6	1,505	29.2
11	Olvit	173,404	10,170	104,324	277,728	37 kW*2	245	2.4	0	0.0
13	Lubmeat	56,070	4,481	45,966	102,036	18.5 kW*3	190	4.2	0	0.0
14	Obrzansk	38,367	1,709	17,531	55,898	18.5 kW*2	26	1.5	0	0.0
15	MLECZ	134,399	5,085	52,162	186,561	75 kW + 37 kW	412	8.1	206	50.0
Total		3,535,284	245,412	2,517,436	6,052,720		42,606	17.4	15,309	35.9

Energy consumption ratio of equipment in factories: 10.258* (E)/(D) = 7.2 %

6.3 Motor

Energy conservation potential of motors in each factory is 2.4 % as shown in Table 6.3.
For motors, standard type induction motors are used but no high-efficiency type motors were observed.

Following are the recommendable energy conservation measures for motors.

(1) Output of load machines for motors

Machines connected to motors, such as blowers and pumps, should be checked for the appropriateness of output, with specific regard to whether the flow rate or pressure is excessive. Such machines should be operated at a proper value in due consideration of the factory production operation.

(2) Controlling the revolution of a motor

For motors connected to pumps and fans used for the transportation of fluids, it is recommended to control the revolution by installing an inverter.

If an inverter is installed to the fan operating with an 80 % load of the motor, a 40 % power saving can be achieved.

(3) Replacement of motors

Large size motors operating under light load should be replaced with small-size motors.

Induction motors for use in factories become less efficient when they are operated under light load. For the countermeasure for such a case, it is advisable to replace motor of excess output, or to adopt the variable speed control.
As shown in Table 6.3, the payback period for the replacement of motors is long, thus making it unfeasible. On the other hand, the installation cost of an inverter is declining owing to the advance in electronic control technologies, making the adoption of inverters easier.

Table 6.3 Energy Conservation Potential of Motor

Electricity: 0.172 PLN/kWh 1 PLN = 35 yen

Item		Energy conservation potential Electricity [MWh/y]	[1,000 PLN/y]	Investment cost [1,000 PLN]	Payback period [year]
1st step					
Subtotal		0	0	0	0.0
2nd step					
1 Steel	Installation of inverter control	134	23	124	5.4
2 Steel	Installation of inverter conrol	2,600	447	1,237	2.8
3 Steel	Installation of inverter control for blower motor	239	41	129	3.1
4 Chemical	Installation of inverter control for pump motor	355	61	154	2.5
5 Chemical	Installation of inverter control for boiler motor	195	34	47	1.4
6 Glass	Installation of inverter control	298	51	197	3.8
7 Machine	Installation of inverter control	257	44	189	4.3
8 Machine	Installation of inverter control	3,000	516	1,457	2.8
9 Food	Installation of inverter control	385	66	189	2.9
10 Food	Replacement of motor	13	2	11	4.9
11 Food	Installaltion of inverter control	333	57	283	4.9
Subtotal		7,809	1,343	4,017	3.0
3rd step					
Subtotal	0	0	0	0	0.0
Total (1st, 2nd and 3rd steps)		7,809	1,343	4,017	3.0

No. Factory	Factory				Motor				
	Heat consumption (A) [GJ/y]	Electricity consumption (B) [MWh/y]	Elctricity consumption (C) [GJ/y]	Energy consumption (D) = (A) + (C) [GJ/y]	Installed capacity [kW]	Energy consumption (E) [MWh/y]	Ratio (E)/(B) [%]	Energy conservation potential of equipment (F) [MWh/y]	(F)/(E) [%]
1 Labedy	679,979	36,940	378,931	1,058,910	1,365	7,632	20.7	134	1.8
2 Ostrowiec	3,419,092	626,637	6,428,042	9,847,134		200,000	31.9	2,600	1.3
3 Laczniknow	261,988	27,963	286,844	548,832	298	18,000	64.4	239	1.3
4 Blachownia	807,953	6,591	67,610	875,563		6,000	91.0	355	5.9
5 Pech	321,185	4,941	50,685	371,870	1,064	4,500	91.1	195	4.3
6 Boruta	70,950	2,024	20,762	91,712		1,800	88.9	0	0.0
7 Ursus	860,645	114,087	1,170,304	2,030,949	3,000	42,300	37.1	3,000	7.1
8 Star	466,821	23,573	241,812	708,633		20,000	84.8	257	1.3
9 Wolomin	792,661	19,380	198,800	991,461	1,243	9,000	46.4	298	3.3
10 Silikaty	75,711	663	6,801	82,512	377	600	90.5	0	0.0
11 Olvit	173,404	10,170	104,324	277,728	2,419	5,000	49.2	0	0.0
12 Koscian	50,083	2,650	27,184	77,267	557	2,000	75.5	13	0.7
13 Lubmeat	56,070	4,481	45,966	102,036	3,010	4,000	89.3	333	8.3
14 Obrzansk	38,367	1,709	17,531	55,898	187	1,500	87.8	0	0.0
15 MLECZ	134,399	5,085	52,162	186,561	1,372	4,900	96.4	385	7.9
Total	8,209,308	886,894	9,097,759	17,307,067		327,232	36.9	7,809	2.4

Energy consumption ratio of equipment in factories: 10.258* (E)/(D) = 19.4 %

6.4 Transformer

Energy conservation potential of transformers in each factory is 1.2 % as shown in Table 6.4. The design conditions and specifications of transformers in the factories were surveyed, which revealed no particular problem in terms of design efficiency.

The power receiving factor varied depending on the factory surveyed, and in 95 % of the factories studied power factor was good, while in 85 % of them it was poor.
Following are the energy conservation measures recommended for transformers.

(1) Integration of transformers

When a plural number of transformers are operating under low load, the secondary load of the transformer should be integrated into one or more transformers to block the primary side of unloaded transformers.

Transformers operating at low load include those installed at the construction under the future expansion plan and those whose capacity have become excessive due to a decline in the production volume. In this respect, consideration should be given to their integration or elimination so as to allow them to be used as transformers of proper capacity based on the future production scheme.

Replacing them with small-capacity transformers is not feasible in terms of the payback period. In the power contract in Poland, the penalty provisions for worse power factor is less strict, and thus the installation of capacitors for improvement of power factor is not so widespread.

In the power contract in Poland, penalty is charged only when the power factor is $\tan \phi < 0.4$ (equivalent to $\cos \phi < 0.86$) and thus no bonus is provided for improvements of power factor.

Table 6.4 Energy Conservation Potential of Transformer

Electricity: 0.172 PLN/kWh Natural gas: 0.514 PLN/m^3_N 1 PLN = 35 yen

Item		Energy conservation potential Electricity [MWh/y]	[PLN/y]	Investment cost [PLN]	Payback period [year]
1st step					
1 Machine	Rearrangement of transformer	46	8	0	0
2 Chemical	Reduction of capacity	34	6	0	0
3 Chemical	Unification of transformers	126	22	40	1.846
4 Food	Adjusting of voltage	33	6	0	0
5 Food	Stop of transformer operation	9	2	0	0
6 Cutout of transformer breaker		1	0	0	0
Subtotal		249	43	40	0.934
2nd step					
Subtotal		0	0	0	0
3rd step					
Subtotal	0	0	0	0	0
Total (1st, 2nd and 3rd steps)		249	43	40	0.934

No. Factory	Factory: Heat consumption (A) [GJ/y]	Electricity consumption (B) [MWh/y]	Elctricity consumption (C) [GJ/y]	Energy consumption (D) = (A) + (C) [GJ/y]	Transformer: Installed capacity [MVA]	Energy consumption (E) [MWh/y]	Ratio (E)/(B) [%]	Energy conservation potential of equipment (F) [MWh/y]	(F)/(E) [%]
2 Ostrowiec	3,419,092	626,637	6,428,042	9,847,134	426.0	18,799	5	0	0.0
3 Lacznikow	261,988	27,963	286,844	548,832	12.6	839	5	0	0.0
4 Blachownia	807,953	6,591	67,610	875,563	96.0	198	5	126	38.2
5 Poch	321,185	4,941	50,685	371,870	4.6	148	5	34	13.8
6 Boruta	70,950	2,024	20,762	91,712	32.0	61	5	0	0.0
8 Star	466,821	23,573	241,812	708,633	40.0	707	5	46	3.9
10 Silikaty	75,711	663	6,801	82,512	0.3	20	5	0	0.0
11 Olivit	173,404	10,170	104,324	277,728	4.7	305	5	33	6.5
12 Koscian	50,083	2,650	27,184	77,267	0.8	80	5	0	0.0
13 Lubmeat	56,070	4,481	45,966	102,036	6.0	134	5	9	4.0
14 Obrzansk	38,367	1,709	17,531	55,898	0.4	51	5	0	0.0
15 MLECZ	134,399	5,085	52,162	186,561	7.4	153	5	1	0.4
Total	5,876,023	716,487	7,349,724	13,225,747		21,495	5	249	0.7

Energy consumption ratio of equipment in factories: 10.258* (E)/(D) = 2.8 %

Transformer energy consumption (E) is assumed to be 5 % of electricity consumption (B)

6.5 Factory Space Heating

The factory study in Poland this time was implemented during the period from July to October and thus factory heating under high load could not be surveyed. In three factories, low-load factory heating was studied; however, no data sufficient for us to quantify the energy conservation potential was obtained.

Following are the energy conservation measures recommended for factory heating.

(1) Prevention of intrusion of outside air into factory buildings

Such countermeasures as repairs of broken portions of window glass and prohibition of leaving the doors open are put into practice.

The opening of the roof ventilation hole should be adjusted according to the standard for the number of ventilation times.

(2) Reinforcement of the heat insulation of the factory buildings

Pair glass and transparent laminate plastic sheets are adopted for windowglass. The overall heat tranfer coefficient of the transparent laminate plastic glass sheet is approximately 50 % that of the single layer glass, and the overall heat tranfer coefficient is nearly identical to that of the pair glass.

(3) Utilization of the heated air at elevated portions in the factory buildings

Since in buildings having a high roof or ceiling, warm air stays in high portions, and thus a fan or jet nozzle should be installed to reduce the temperature difference between the floor surface and the high portions.

(4) Enclosure of working space

The working space in the factory building should be set up to enclose their floor surface to the ceiling with wall material and synthetic resin sheet and thereby prevent the outflow of warm air. This has already been implemented in some factories.

(5) Adoption of localized heating

In place of the heating of the entire factory, it is advisable to implement localized heating for workers in the limited working areas. In this case, heating with infrared rays is advantageous.

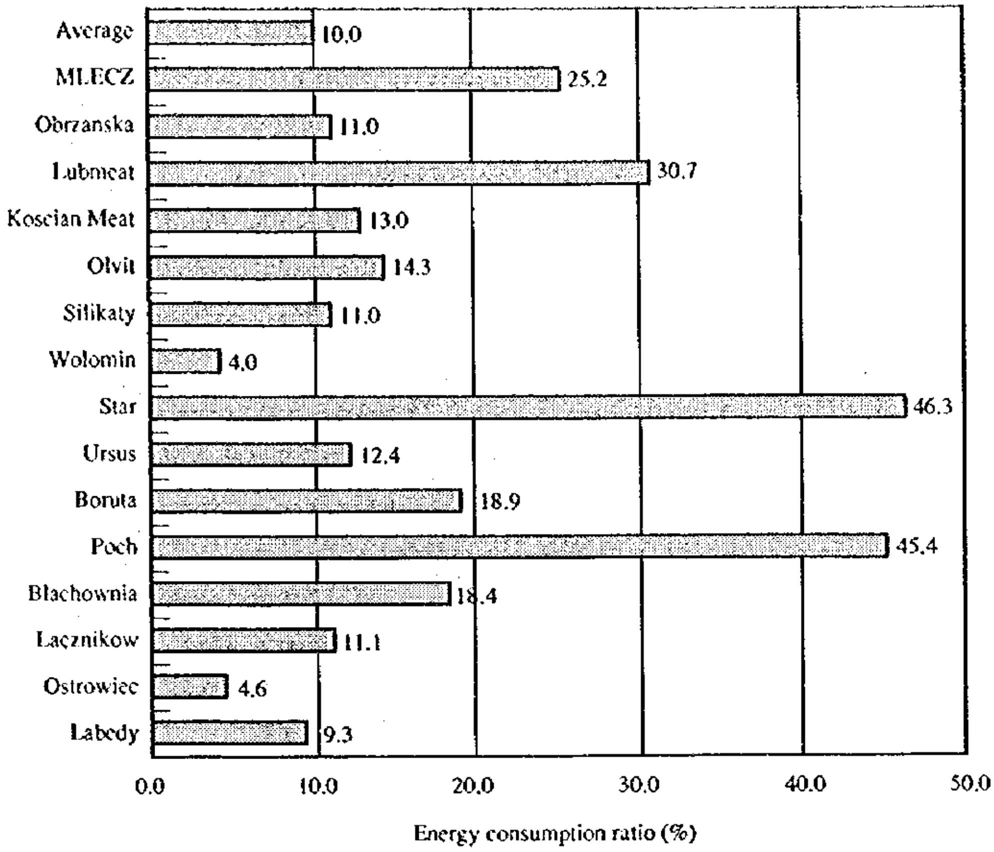
As shown in Table 6.5, heating for the factory buildings is not implemented in such factories where heat generating elements are installed in the building as in the steel-making industry and non-metallic industry, whereas in some factories in the machine manufacturing industry, the chemical industry, etc., energy used for space heating accounts for as much as 40 % or more of the total energy used annually.

It is stipulated in the law in Poland that the room temperature of workers' working areas must be kept at 16 °C or higher; however, it is necessary to set up criteria depending on the case and thus make the effort for reduction of heating energy consumption.

Table 6.5 Energy Conservation Ratio of Space Eeating in Factories

Industry sector	Factory [Factory]	Energy consumption in factory [GJ/y]	Energy consumption for space heating [GJ/y]	Ratio of space heating [%]
Steel-making	1 Labedy	1,058,910	98,357	9.3
	2 Ostrowiec	9,847,134	455,901	4.6
	3 Lacznikow	548,832	61,120	11.1
Chemical	4 Blachownia	875,563	160,848	18.4
	5 Poch	371,870	168,718	45.4
	6 Boruta	91,712	17,340	18.9
Machinery manufacturing	7 Ursus	2,030,949	252,317	12.4
	8 Star	708,633	328,320	46.3
Non-metallic	9 Wolomin	991,461	40,089	4.0
	10 Silikaty	82,512	9,085	11.0
Food processing	11 Olivit	277,728	39,586	14.3
	12 Koscian Meat	77,267	10,017	13.0
	13 Lubmeat	102,036	31,315	30.7
	14 Obrzanska	55,898	6,139	11.0
	15 MLECZ	186,561	47,040	25.2
Total	Average	17,307,067	1,726,192	10.0

Energy consumption ratio of space heating



6.6 Boilers

The energy conservation potential of boilers is 7.1 % as shown in Table 6.6.
The major types of boilers used in the factories surveyed include coal-fired flue tube-smoke steam boilers, coal-fired stoker water tube boilers, and hot water boilers. As small-size boilers, natural gas-fired once-through hot water boilers and fuel oil-fired once-through steam boilers are installed. For dust collectors, some factories are equipped with cyclone type dust collectors, but no electric precipitator or bag filter type dust collectors of high dust collecting efficiency have been installed. Nor are flue gas desulfurization equipment nor flue gas denitrification equipment installed.

Following are energy conservation measures recommended for boilers.

(1) Improvement of the combustion air ratio of coal-fired boilers

Coal-fired stoker type water tube boilers are operated at the air ratio of 2 to 6. In other words, the amount of air 2 times to 6 times larger than necessary is used, and as a result the excess air constitutes an exhaust gas heat loss. The air ratio should be 2 or lower for boiler operation. Reducing the air ratio from 6 to 3 allows fuel consumption to be reduced by approximately by 25 %. Some boilers operating at the air ratio of 3 or lower emit black smoke from the stack and hence also a dust collector should be installed or maintained well.

(2) Maintenance of air preheaters

Many boilers decline in the efficiency due to the adhesion of coal dust on the heating surface. By cleaning of the heating surface, the efficiency can be recovered and fuel consumption can be reduced.

(3) Improvement of a coal feeder

Many coal-fired boilers are equipped with a stoker-type feeder, which is, however, not sufficient to accommodate load variations. Adopting a stoker type coal feeder with a spreader will allow the adjustment range to be expanded so as to cope with a load fluctuation, thus making it possible to operate at the air ratio of around 1.5.

Natural gas-fired boilers and fuel oil-fired boilers, which have been operating for 1 to 2 years since the start of operation, are running in favorable condition at the air ratio of 1.3 to 1.5.

With regard to coal-fired boilers, it is necessary to make combustion at low air ratio and install a dust collector of high efficiency in order to comply with possibly more strict standard in the future when the control level for the emission such as dust, SOx, NOx, CO_2 is made lower.

Considering a possible increase in the emission fee or penalty charge for the pollutant emission of coal-fired boilers, many factories have a plan to eliminate coal-fired boilers and replace them with natural gas-fired boilers. Since the price of natural gas per unit of heat value is two times that of coal, the payback period for installing natural gas-fired boiler newly is 5 years or longer even with the fee or charge on the coal-fired boilers taken. Here, however, compared to the installation of flue gas desulfurization equipment with the coal-fired boiler, it will be more feasible to adopt natural gas-fired boilers, for which the payback period will be within 5 years.

Thus, replacement with natural gas-fired boilers is expected to gradually increase in the future.

Table 6.6 Energy Conservation Potential of Boiler

Coal: 170 PLN/t Electricity: 0.172 PLN/kWh Natural gas: 0.514 PLN/m^3_N 1 PLN = 35 yen

Item			Energy conservation potential Heat [GJ/y]	[Fuel]	[1,000 PLN/y]	Investment cost [1,000 PLN]	Payback period [year]
1st step							
1	Steel	Improving of air ratio	8,198	Coal	63	0	0.0
2	Machine	Improving of air tatio	16,765	Coal	130	0	0.0
3	Chemical	Improving of air ratio	52,866	Coal	409	0	0.0
4	Non-metallic	Improving of air ratio	5,542	Coal	43	0	0.0
5	Food	Improving of air ratio	6,244	Coal	48	0	0.0
6	Food	Improving of air ratio	1,842	Coal	14	0	0.0
7	Food	Improving of air ratio	8,063	Coal	62	0	0.0
8	Food	Maintenance of air preheater	2,343	Coal	18	0	0.0
Subtotal			101,863		193	0	0.0
2nd step							
Subtotal			0		0	0	0.0
3rd step							
Subtotal			0		0	0	0.0
Total (1st, 2nd and 3rd steps)			101,863		193	0	0.0

No.	Factory	Factory: Heat consumption (A) [GJ/y]	Electricity consumption (B) [MWh/y]	Elctricity consumption (C) [GJ/y]	Energy consumption (D) = (A) + (C) [GJ/y]	Boiler: Fuel kind	Installed capacity [t/h]	Energy consumption (E) [GJ/y]	Ratio (E)/(A) [%]	Energy conservation potential of equipment (F) [GJ/y]	(F)/(E) [%]
1	Labedy	679,979	36,940	378,931	1,058,910	Gas	4 MW*3	98,357	14.5	0	0.0
3	Laczniko	261,988	27,963	286,844	548,832	Coal	5 Gcal/h*4	80,099	30.6	8,198	10.2
5	Poch	321,185	4,941	50,685	371,870	Coal	16 t/h*2	318,472	99.2	52,866	16.6
7	Ursus	860,645	114,087	1,170,304	2,030,979	Coal	32 t/h*4	565,000	65.6	16,765	3.0
9	Wolomin	792,661	19,380	198,800	991,461	Coal	950 Mcal/h*4	0	0.0	0	0.0
10	Silikaty	75,711	663	6,801	82,512	Coal	3.8 t/h*2	75,711	100.0	5,542	7.3
11	Olvit	173,404	10,170	104,324	277,728	Oil	1.5 t/h	15,078	8.7	0	0.0
12	Koscian	50,083	2,650	27,184	77,267	Gas	4 t/h*2	50,083	100.0	0	0.0
13	Lubmeat	56,070	4,481	45,966	102,036	Coal	5 t/h*3	56,070	100.0	6,244	11.1
14	Obrzansk	38,367	1,709	17,531	55,898	Coal	2.2 t/h*2	38,367	100.0	1,842	4.8
15	MLECZ	134,399	5,085	52,162	186,561	Coal	10 t/h*3	134,375	100.0	10,406	7.74
Total		3,444,492	228,069	2,339,532	5,784,024			1,431,612	41.6	101,863	7.1

Energy consumption ratio of equipment in factories: (E)/(D) = 24.8 %

6.7 Heating Furnaces

The energy conservation potential of the slab, bloom and billet reheating furnace in rolling mills and the steel product heating furnaces in the forging mills is 26.5 % as shown in Table 6.7.

Slab, bloom and billet reheating furnaces in the rolling mills and the steel product heating furnace in the forging mills directly heat steel product with burnt gas and the fuel used is natural gas. Following are the energy conservation measures recommended for heating furnaces.

(1) Improvement of combustion air ratio

Slab, bloom and billet reheating furnaces in the rolling mills are operating at the air ratio of 1.2 to 1.8, which should be lowered to 1.1 to 1.3. Decreasing the air ratio from 1.8 at the exhaust gas temperature of 850 °C to 1.3 will achieve a 15 % fuel saving.

(2) Reinforcing the heat insulation of the furnace body

The radiation heat loss from the furnace body can be reduced by reinforcing the heat insulation. Use of ceramic fiber for insulating the batch furnaces such as heating furnaces in forging mills is advantageous. In addition to heat radiation loss from the furnace body, heat storage loss of the refractory material is equally large in batch furnaces, and in this case, the use of lightweight ceramic fiber is advantageous. This is being implemented on heating furnaces in forging mills one after another in Poland.

(3) Setting the criteria for heat holding operation

In order to reduce the fuel consumption during the shutdown or heat-holding of a heating furnace, it is necessary to set up the heat holding criteria.

Since the improvement of air ratio leads to a substantial energy conservation effect as shown in Table 6.7, the payback period within 3 years for improvement of measuring equipment and control devices is possible. Also the payback period for reinforcing the heat insulation with ceramic fiber is within 5 to 6 years, and this should be implemented with priority assigned.

Table 6.7 Energy Conservation Potential of Heating Furnace

Coal: 170 PLN/t Electricity: 0.172 PLN/kWh Natural gas: 0.514 PLN/m^3_N 1 PLN = 35 yen

Item		Energy conservation potential Electricity [GJ/y]	 [1,000 PLN/y]	Total saving [1,000 PLN/y]	Investment cost [1,000 PLN]	Payback period [year]
1st step						
1 Steel	Improvement of air ratio of shape mill	5,614	81	81	0	0.0
2 Steel	Improvement of holding heat standard	5,012	73	73	0	0.0
3 Steel	Improvement of operation standard in low load	12,311	178	178	0	0.0
4 Steel	Improvement of air ratio of plate mill	1,800	26	26	0	0.0
5 Steel	Reinforcement of close of opening	2,342	34	34	57	1.7
6 Steel	Improvement of air ratio of bar mill	191,490	2,773	2,773	0	0.0
7 Steel	Improvement of air ratio of forging (Heat)	162,744	2,356	2,614	4,000	1.5
	Improvement of air ratio of forging (Electricity)	1,499 MWh/y	258			
Subtotal		381,313	5,779	5,779	4,057	0.7
2nd step						
8 Steel	Insulation of ceramic fiber of shape mill	12,631	183	183	857	4.7
9 Steel	Insulation of ceramic fiber of plate mill	7,169	104	104	571	5.5
10 Steel	Insulation of ceramic fiber of bar mill	37,079	537	537	1,143	2.1
11 Steel	Insulation of ceramic fiber of bar mill 2	37,079	537	537	1,429	2.7
12 Steel	Improvement of openings	24,889	360	360	143	0.4
Subtotal		118,847	1,721	1,721	4,143	2.4
3rd step						
13 Steel	Introduction of hot charge rolling	33,483	485	485	875	1.8
14 Steel	Increase of hot charge rolling ratio	170,157	2,464	2,464	7,143	2.9
Subtotal		203,640	2,948	2,948	8,019	2.7
Total (1st, 2nd and 3rd steps)		703,800	10,448	10,448	6,218	1.6

No. Factory	Factory Heat consumption (A) [GJ/y]	 Electricity consumption (B) [MWh/y]	 Elctricity consumption (C) [GJ/y]	 Energy consumption (D) = (A) + (C) [GJ/y]	Heating furnace Installed capacity [t/h]	 Energy consumption (E) [GJ/y]	 Ratio (E)/(A) [%]	 Energy conservation potential of equipment (F) [GJ/y]	 (F)/(E) [%]
1 Labedy	679,979	36,940	378,931	1,058,910	60 t/h, 8 t/h	428,299	63.0	80,362	18.8
2 Ostrowiec	3,419,092	626,637	6,428,042	9,847,134	200 t/h	2,230,395	65.2	623,438	28.0
Total	4,099,071	663,577	6,806,973	10,906,044		2,658,694	64.9	703,800	26.5

Energy consumption ratio of equipment in factories: (E)/(D) = 24.4 %

7. APPENDIX

APPENDIX

Timetable of the Factory Energy Audit

A. Preliminary audit (at the first study)

No.	Date		Schedule
1	1997 16 Mar.	Sun.	Departure from Tokyo, Arrive at Warsaw
2	17 Mar.	Mon.	Meeting at Embassy of Japan, Meeting with KAPE Explanation of Inception Report
3	18 Mar.	Thu.	Meeting with Steering Committee
4	19 Mar.	Wed.	Energy audit in URSUS (Tractor)
5	20 Mar.	Thurs.	Discussion of Inception Report
6	21 Mar.	Fri.	Meeting with KAPE
7	22 Mar.	Sat.	Holiday
8	23 Mar.	Sun.	Move from Warsaw to Gliwice
9	24 Mar.	Mon.	Energy audit in ZEW (Carbon electrode) Energy audit in BLACHOWNIA (Chemical)
10	25 Mar.	Thu.	Move from Gliwice to Warsaw Energy audit in LABEDY (Steel) Energy audit in OSTROWICE (Steel)
11	26 Mar.	Wed.	Visiting JETRO Meeting with KAPE
12	27 Mar.	Thurs.	Discussing and signing the Minutes of Meeting Report to Embassy of Japan
13	28 Mar.	Fri.	Departure from Warsaw, arrive at Vienna Report to JICA Austria Office
14	29 Mar.	Sat.	Departure from Vienna
15	30 Mar.	Sun.	Arrive at Tokyo

B. Simplified energy audit (at the second study)

No.	Date		Schedule
1	1997 15 July	Tue.	Departure from Tokyo Arrive at Warsaw
2	16 July	Wed.	Meeting at Embassy of Japan Meeting with KAPE
3	17 July	Thurs.	Meeting with KAPE and local consultants
4	18 July	Fri.	Meeting with consultants (Truck & Tractor)
5	19 July	Sat.	Holiday
6	20 July	Sun.	Holiday
7	21 July	Mon.	Energy audit in URSUS (Tractor)
8	22 July	Tue.	Ditto
9	23 July	Wed.	Ditto Departure from Tokyo, arrive at Warsaw (Mr. Maruyama)
10	24 July	Thurs.	Move from Warsaw to Gliwice Meeting with consultants (Steel)
11	25 July	Fri.	Energy audit in LABEDY (Steel) Departure from Warsaw (Dr. Takemura & Ms. Sato)
12	26 July	Sat.	Holiday Arrive at Tokyo (Dr. Takemura & Ms. Sato)
13	27 July	Sun.	Holiday
14	28 July	Mon.	Energy audit in LABEDY (Steel)
15	29 July	Tue.	Ditto Move from Gliwice to Ostrowiec
16	30 July	Wed.	Energy audit in OSTROWIEC (Steel)
17	31 July	Thurs.	Ditto
18	1 Aug.	Fri.	Ditto Move from Ostrowiec to Warsaw (Mr. Usui & Mr. Fukushima)
19	2 Aut.	Sat.	Holiday Departure from Warsaw (Mr. Usui) Departure from Tokyo and arrive at Warsaw (Mr. Sugimoto)
20	3 Aug.	Sun.	Holiday Move from Ostrowiec to Starachowice, Warsaw to Starachwice (Mr. Sugimoto & Mr. Fukushima) Arrive at Tokyo (Mr. Usui)
21	4 Aug.	Mon.	Energy audit in STAR (Truck)
22	5 Aug.	Tue.	Ditto
23	6 Aug.	Wed.	Ditto
24	7 Aug.	Thurs.	Move from Starachowice to Warsaw
25	8 Aug.	Fri.	Analysis of data in KAPE
26	9 Aug.	Sat.	Holiday
27	10 Aug.	San.	Holiday Departure from Tokyo, arrive at Warsaw (Mr. Kato & Mr. Miyake)

No.	Date		Schedule
28	11 Aug.	Mon.	Meeting with consultants (Glass, Silica & Chemical)
29	12 Aug.	Tue.	Energy audit in WOLOMIN (Glass)
30	13 Aug.	Wed.	Ditto
			Departure from Warsaw (Mr. Maruyama & Mr. Nozawa)
31	14 Aug.	Thurs.	Energy audit in WOLOMIN (Glass)
			Arrive at Tokyo (Mr. Maruyama & Mr. Nozawa)
32	15 Aug.	Fri.	National Holiday
33	16 Aug.	Sat.	Holiday
34	17 Aug.	Sun.	Move from Warsaw to Gliwice
35	18 Aug.	Mon.	POCH (Chemical)
36	19 Aug.	Tue.	Ditto
37	20 Aug.	Wed.	Ditto
			Move from Gliwice to Warsaw
38	21 Aug.	Thurs.	Analysis in KAPE
39	22 Aug.	Fri.	Visit at Regional Energy Conservation Agency (RAPE)
			Energy audit in SILIKATY (Silica block)
40	23 Aug.	Sat.	Holiday
41	24 Aug.	Sun.	Holiday
42	25 Aug.	Mon.	Energy audit in SILIKATY (Silica block)
43	26 Aug.	Tue.	Ditto
			Move from Radom to Gliwice
44	27 Aug.	Wed.	Energy audit in BLACHOWNIA (Chemical)
45	28 Aug.	Thu.	Ditto
46	29 Aug.	Fri.	Ditto
			Move from Gliwice to Warsaw
47	30 Aug.	Sat.	Holiday
48	31 Aug.	Sun.	Holiday
49	1 Sep.	Mon.	Analysis of data in KAPE
			Departure from Tokyo, arrive at Warsaw (Mr. Honda)
			Departure from Warsaw (Mr. Miyake, Mr. Kato)
50	2 Sep.	Tue.	Meeting with consultants (Food)
			Arrive at Tokyo (Mr. Miyake & Mr. Kato)
			Report to Embassy of Japan
51	3 Sep.	Wed.	Move from Warsaw to Koscian
52	4 Sep.	Thurs.	Energy audit in KOSCIAN Meat (Meat)
53	5 Sep.	Fri.	Ditto
54	6 Sep.	Sat.	Holiday
55	7 Sep.	Sun.	Holiday

No.	Date		Schedule
56	8 Sep.	Mon.	Energy audit in OBRZANSKA (Dairy)
57	9 Sep.	Tue.	Ditto
58	10 Sep.	Wed.	Move from Poznan to Gdansk Meeting with consultants (Vegetable oil)
59	11 Sep.	Thurs.	Energy audit in OLVIT (Vegetable oil)
60	12 Sep.	Fri.	Ditto
61	13 Sep.	Sat.	Holiday
62	14 Sep.	Sun.	Holiday
63	15 Sep.	Mon.	Energy audit in OLVIT (Vegetable oil) Move from Gdansk to Warsaw
64	16 Sep.	Tue.	Data analysis in KAPE
65	17 Sep.	Wed.	Move from Warsaw to Lublin Energy audit in LUBMEAT (Meat)
66	18 Sep.	Thurs.	Ditto
67	19 Sep.	Fri.	Ditto Move from Lublin to Warsaw
68	20 Sep.	Sat.	Holiday Departure from Tokyo, arrive at Warsaw (Dr. Takemura) Departure from Warsaw (Mr. Sugimoto, Mr. Honda & Mr. Koyamada)
69	21 Sep.	Sun.	Holiday Arrive at Tokyo (Mr. Sugimoto, Mr. Honda & Mr. Koyamada)
70	22 Sep.	Mon.	Meeting with KAPE
71	23 Sep.	Tue.	Making Progress Report and Minutes of Meeting
72	24 Sep.	Wed.	Ditto
73	25 Sep.	Thurs.	Signing of Minutes of Meeting Submitting Progress Report Report to Embassy of Japan
74	26 Sep.	Fri.	Departure from Warsaw, arrive at Vienna (Dr. Takemura & Fukushima) Report to JICA Austria Office Departure from Warsaw (Mr. Konishi)
75	27 Sep.	Sat.	Arrive at Tokyo (Mr. Konishi) Departure from Vienna (Dr. Takemura & Mr. Fukushima)
76	28 Sep.	Sun.	Arrive at Tokyo (Dr. Takemura & Mr. Fukushima)

C. Detailed energy audit (at the fourth study)

No.	Date		Schedule
1	1998 1 Sep.	Tue.	Departure from Tokyo Arrive at Warsaw
2	2 Sep.	Wed.	Meeting at Embassy of Japan, JOCV, KAPE Inspection of equipment
3	3 Sep.	Thurs.	Unpack and inspection of equipment
4	4 Sep.	Fri.	Function test of equipment
5	5 Sep.	Sat.	Holiday
6	6 Sep.	Sun.	Holiday
7	7 Sep.	Mon.	Function test of equipment
8	8 Sep.	Tue.	Ditto
9	9 Sep.	Wed.	Ditto
10	10 Sep.	Thurs.	Lecture of audit and equipment
11	11 Sep.	Fri.	ditto, Meeting with consultant (Glass)
12	12 Sep.	Sat.	Holiday, Departure from Warsaw (Mr. Oshima)
13	13 Sep.	Sun.	Holiday, Arrive at Tokyo (Mr. Oshima)
14	14 Sep.	Mon.	Energy audit in WOLOMIN (Glass)
15	15 Sep.	Tue.	Ditto
16	16 Sep.	Wed.	Ditto
17	17 Sep.	Thurs.	Ditto
18	18 Sep.	Fri.	Ditto
19	19 Sep.	Sat.	Holiday Departure from Tokyo and arrive at Warsaw (Mr. Nozawa, Mr. Honda)
20	20 Sep.	Sun.	Holiday
21	21 Sep.	Mon.	Move from Warsaw to Poznan, Meeting with consultant (Dry milk) Analyzing and meeting (WOLOMIN, Mr. Kato)
22	22 Sep.	Tue.	Energy audit in MLEKA (Dry milk), Analyzing and meeting (WOLOMIN, Mr. Kato)
23	23 Sep.	Wed.	Energy audit in MLEKA (Dry milk)
24	24 Sep.	Thurs.	ditto
25	25 Sep.	Fri.	ditto
26	26 Sep.	Sat.	Holiday, Departure from Warsaw (Dr. Takemura, Mr. Kato)
27	27 Sep.	Sun.	Holiday, Arrive at Tokyo (Dr. Takemura, Mr. Kato), Departure from Tokyo, arrive at Warsaw (Mr. Nagai)

No.	Date		Schedule
28	28 Sep.	Mon.	Energy audit in MLEKA (Dry milk), Move from Poznan to Warsaw, Departure from Tokyo, Arrive at Warsaw (Mr. Usui)
29	29 Sep.	Tue.	Meeting with consultant (Tractor) Analyzing and meeting (MLEKA, Mr. Honda)
30	30 Sep.	Wed.	Energy audit in URSUS (Tractor), Analyzing and meeting (MLEKA, Mr. Honda)
31	1 Oct.	Thurs.	Energy audit in URSUS (Tractor)
32	2 Oct.	Fri.	Ditto
33	3 Oct.	Sat.	Holiday, Departure from Warsaw (Mr. Sugimoto)
34	4 Oct.	Sun.	Holiday, Arrive at Tokyo (Mr. Sugimoto)
35	5 Oct.	Mon.	Energy audit in URSUS (Tractor)
36	6 Oct.	Tue.	Ditto, Departure from Tokyo, Arrive at Warsaw (Mr. Maruyama, Mr. Miyake)
37	7 Oct.	Wed.	Move from Warsaw to Lodz, Meeting with consultant (Dyestuff), Analyzing and meeting (Tractor, Mr. Nozawa)
38	8 Oct.	Thurs.	Energy audit in BORUTA (Dyestuff), Analyzing and meeting (Tractor, Mr. Nozawa)
39	9 Oct.	Fri.	Energy audit in BORUTA (Dyestuff)
40	10 Oct.	Sat.	Holiday
41	11 Oct.	Sun.	Holiday
42	12 Oct.	Mon.	Energy audit in BORUTA (Dyestuff)
43	13 Oct.	Tue.	Ditto
44	14 Oct.	Wed.	Ditto, Move from Lods to Warsaw, Departure from Warsaw (Mr. Nozawa, Mr. Honda)
45	15 Oct.	Thurs.	Meeting with consultant (Steel), Analyzing and meeting (BORUTA, Mr. Miyake), Arrive at Tokyo (Mr. Nozawa, Mr. Honda)
46	16 Oct.	Fri.	Energy audit in LACZNIKOW (Steel), Analyzing and meeting (BORUTA, Mr. Miyake)
47	17 Oct.	Sat.	Holiday
48	18 Oct.	Sun.	Holiday, Departure from Tokyo, Arrive at Warsaw (Dr. Takemura)
49	19 Oct.	Mon.	Energy audit in LACZNIKOW (Steel)
50	20 Oct.	Tue.	Ditto
51	21 Oct.	Wed.	Ditto
52	22 Oct.	Thurs.	Ditto
53	23 Oct.	Fri.	Analyzing data, Analyzing and meeting (LACZNIKOW, Mr. Maruyama)
54	24 Oct.	Sat.	Holiday
55	25 Oct.	Sun.	Holiday

No.	Date		Schedule
56	26 Oct.	Mon.	Analyzing data, Analyzing and meeting (LACZNIKOW, Mr. Maruyama)
57	27 Oct.	Tue.	Analyzing data, Making Progress Report
58	28 Oct.	Wed.	Energy Conservation Seminar (at Warsaw University of Technology), Analyzing data, Making Progress Report
59	29 Oct.	Thurs.	Making Progress Report
60	30 Oct.	Fri.	Steering Committee, Departure from Warsaw (Mr. Maruyama, Mr. Miyake)
61	31 Oct.	Sat.	Holiday, Departure from Warsaw (Mr. Konishi, Mr. Usui, Mr. Nagai, Mr. Koyamada), Arrive at Tokyo (Mr. Maruyama, Mr. Miyake)
62	1 Nov.	Sun.	Holiday, Arrive at Tokyo (Mr. Konishi, Mr. Usui, Mr. Nagai, Mr. Koyamada)
63	2 Nov.	Mon.	Meeting and Signing of Minutes of Meeting, Report to Embassy of Japan
64	3 Nov.	Tue.	Departure from Warsaw, arrive at Vienna (Dr. Takemura, Mr. Kimura, Mr. Fukushima) Report to JICA Austria Office
65	4 Nov.	Wed.	Departure from Vienna (Dr. Takemura, Mr. Kimura, Mr. Fukushima)
66	5 Nov.	Thurs.	Arrive at Tokyo (Dr. Takemura, Mr. Kimura, Mr. Fukushima)

JICA