5.1.2 Energy Consumption Status

(1) Trend of production amount

Table 5.1.3 Trend of Production

(t/y)

	1992	1993	1994	1995	1996
Raw oil	41,118	50,520	44,470	44,733	49,928
Refined oil	8,292	8,848	2,180	4,345	12,749
Hydrogenated oil	-	9,704	13,166	14,827	14,169
Margarine	34,140	36,388	34,534	30,725	26,940
Production total	42,432	54,940	49,800	49,897	53,858

(2) Trend of energy consumption

Table 5.1.4 Trend of Energy Consumption

	Unit	1992	1993	1994	1995	1996
Fuel oil	t	305	360	308	289	359
Steam	t	63,800	74,058	66,980	60,530	55,553
Electricity	MWh	9,453	10,674	10,715	10,964	10,070
Water	1,000 m^3	1,386	1,458	1,190	936	1,505

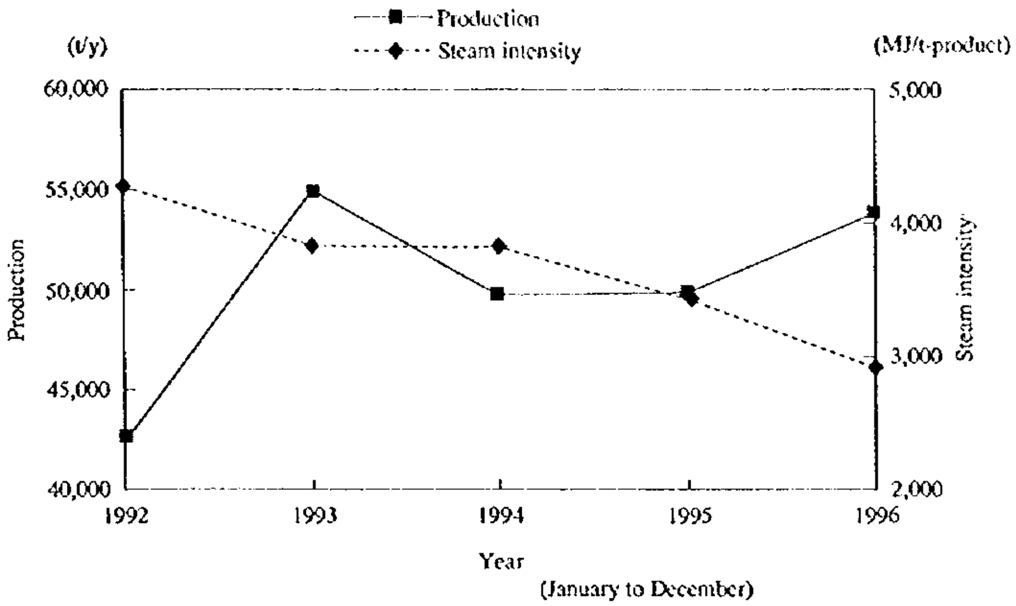
(3) Trend of energy intensity

Steam intensity is improving.

Table 5.1.5 Trend of Energy Intensity

	Unit	1992	1993	1994	1995	1996
Consumption						
Fuel oil	GJ	12,810	15,120	12,936	12,138	15,078
Steam	GJ	181,830	211,053	190,893	172,510	158,326
Electricity	GJ	96,950	109,472	109,893	112,446	103,278
Intensity						
Fuel oil	MJ/t-product	302	299	260	243	280
Steam	MJ/t-product	4,285	3,842	3,833	3,457	2,940
Electricity	MJ/t-product	2,285	1,993	2,207	2,254	2,126
Intensity total	MJ/t-product	6,872	6,134	6,300	5,954	5,346

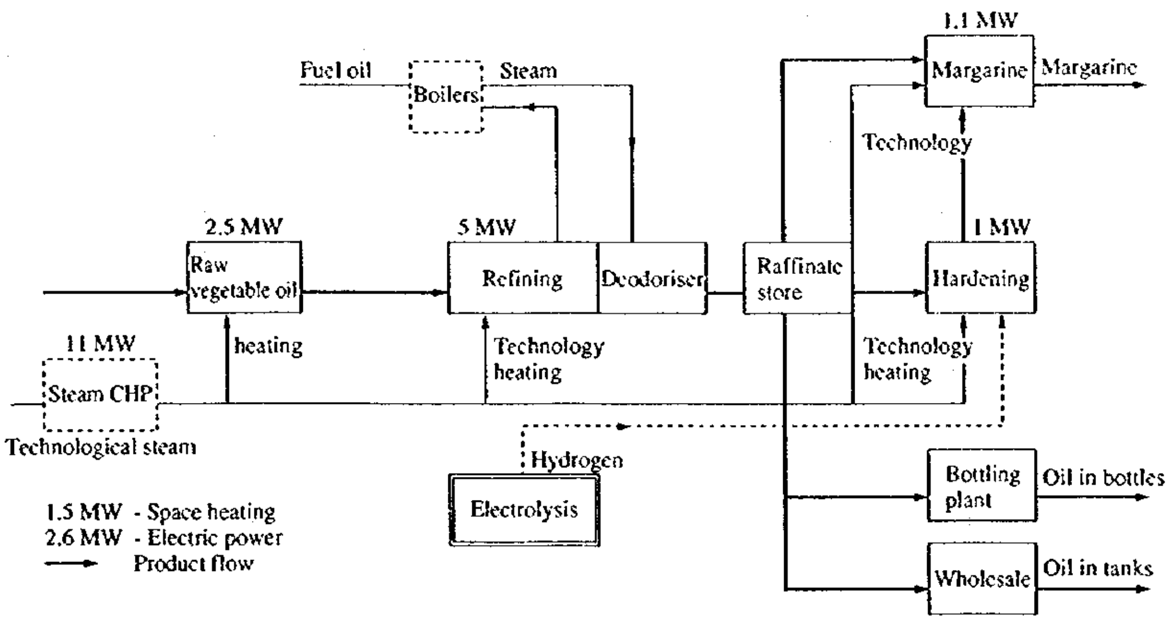
Figure 5.1.4 Trend of Production and Steam Intensity



There have been fluctuations in the production items and the quantities for these 5 years, during which the production in 1992 was small, while the energy intensity was high, as shown in Figure 5.1.5. In 1995 and the subsequent years, the production has increased with energy intensity declining.

(4) Energy flow

Figure 5.1.5 Energy Flow



5.1.3 Energy Management Status

(1) Setting energy conservation targets

a. Setting the target value

No specific target value has been set. It is essential to set a target through a correct understanding of energy consumption.

b. Problems in promoting energy conservation

The fund seems insufficient. The technical level is being upgraded by the supporting group.

(2) Systematic activities

a. Setting up a dedicated section for energy conservation

No dedicated section is provided. This section should be provided particularly for a certain period.

b. Setting up an energy conservation committee

The committee for promoting energy conservation is not provided. To promote energy conservation, systematic activities are essential.

c. Management stance toward energy conservation

The management is positive for promotion of energy conservation and is planning modernization of the facilities.

The general manager of the plant recognizes that energy conservation leads to cost reduction and is enthusiastically engaged in collecting information.

(3) Data-based management

a. Grasping the amount of energy used

They keep good track of the energy consumption in the entire factory.

b. Grasping the energy used by major facility

It is necessary to keep track of energy consumption by each major facility for energy conservation. The current status does not seem to be satisfactory but measurement cases are available.

c. Grasping the energy intensity for each major product

Although the energy intensity by product is used for cost management, this is not based on measured data.

d. Installation of measuring equipment

Although the flow rates of steam, etc. and energy consumption on the major facilities should be measured to allow grasping the energy consumption, measuring equipment installed are apparently insufficient. Addition of measuring equipment is essential in the future.

e. Production management and cost management

Data is managed relatively well.

(4) Plant engineering

Maintenance is relatively good. Heat insulation of the buildings and components is desirable for promotion of energy conservation. Proper actions should be taken to containers that emit a large amount of heat.

5.1.4 Problems and Measures related to Energy Use

(1) Comparison of the energy intensity with the excellent factory

Table 5.1.6 shows the result of comparing the energy intensity of Olvit with that of the excellent factory.

The difference in the energy intensity between Olvit and the excellent factory is 2,445 MJ/t.

For the electricity intensity, Olvit consumes approximately 50 % for electrolytic hydrogenation, while the excellent factory purchases hydrogen from the external company. Therefore, the electricity intensity of the excellent factory is about a half of that of Olvit. This means that, except for the electricity for electrolytic hydrogeneration, the electricity intensity of Olvit is equivalent to that of the excellent factory. The steam intensity of Olvit for processes is 1.66 times larger than that of the excellent factory, while its steam intensity for heating is 7.34 times larger than that of the excellent factory.

Table 5.1.6 Comparison of Energy Intensity

	Unit	OLVIT	Excellent factory	Difference
Electricity	MJ/t	1,916	1,026	890
1) Process	MJ/t	(1,026)	(1,026)	(0)
2) Electrolysis	MJ/t	(890)	(0)	(890)
Steam	MJ/t	2,940	1,425	1,515
1) Process	MJ/t	(2,205)	(1,325)	(880)
2) Heating	MJ/t	(735)	(100)	(635)
Fuel oil	MJ/t	294	252	42
Total	MJ/t	5,150	2,703	2,447

According to Table 5.1.6, the energy conservation potential of Olvit is 47 %. However, if electricity for electrolytic hydrogeneration and steam for heating are excluded, it is 26 %.

(2) Estimating the energy conservation potential

(2)-1 Difference due to external factors

Both Olvit and the excellent factory produce refined oil and margarine, and there is no intensity difference caused by the differences in the materials and products.

Olvit has hydrogen gas generation plant by electrolysis method, but excellent factory purchases hydrogen gas from outside. Therefore, electricity for electrolytic plant of Olvit is considered as an external factor. (890 MJ/t)

Olvit is located in a cold region and consumes much energy for heating. Table 5.1.7 shows steam used by each group in winter. The result of factory survey and discussion revealed that the amount of electricity used for heating and electrolysis is approximately 50 % of the entire electricity consumption.

Table 5.1.7 Steam Balance

9:00 -- 22:00, 19 March 1996

No.	Description	Dia. (mm)	Consumption (kg/h)
Z1	Supply	126	7,131
	Distribution		
1	Margarine, labs, bottling, social build	82.5	1,487
2	Storage of refined oil	70	579
3	Refining; neutralization, bleaching	82.5	476
4	Electrolysis, laundry, garages	70	479
5	Hydrogenation	82.5	407
6	Reserve	82.5	0
7	Rectification-column K2	70	0
8	Raw oil, settling tank, main office	95	1,821
9	Rectification-column K1	70	495
10	Refining, heating (workshop, changing)	51	1,100
11	Rectification-column K3	70	0
	Total		6,844

Pressure: 1.4 MPa (G), Temperature: 220 °C

Table 5.1.8 shows the monthly production and steam consumption in 1996. Steam used in winter is 2.2 times larger than that in summer, indicating that it is larger than the amount used by the excellent factory (1.3 times).

Table 5.1.9 shows the steam intensity in winter and summer. If the steam intensity in summer is the basis of the steam intensity used for processes, the increase in winter is heat radiation from the equipment in processes plus heating energy. The ratio can roughtly be estimated as follows:

Steam consumption	Olivit	Excellent factory
1. Process in summer	100 %	100 %
2. Heat loss of process in winter	10 %	10 %
3. Heating	110 %	20 %

Assuming the heating period to be six months, the annual steam consumption rate is 75 % for processes and 25 % for heating. Since the heating period is four months at the excellent factory, the rate is 93 % for processes and 7 % for heating. Therefore, the steam intensity of Olvit is 635 MJ/t higher than that of the excellent factory because Olvit is located in a cold region. (See Table 5.1.6)

Olvit operates the heating facility for 2 months more than that of excellent factory. Difference in heating period is considered as an external factor. Steam intensity differences for heating of Olvit for these 2 months are as follws:

$635 \times 2/6 = 212$ MJ/t

Therefore, energy intensity for the external factors is as follows:

1)	Electricity of electrolysis plant :	890 MJ/t
2)	Steam in heating period for 2 months:	212 MJ/t
	Total	1,102 MJ/t

Table 5.1.8 Monthly Energy Consumption and Production in 1996

	January	February	March	April	May	June
Production (t)	4,084	3,334	4,451	2,522	4,789	3,426
Steam intensity (MJ/t)	4,703	6,474	3,990	4,225	2,525	2,677

	July	August	September	October	November	December
Production (t)	2,731	6,536	5,228	6,241	5,282	5,231
Steam intensity (MJ/t)	1,384	1,588	2,270	1,975	2,382	3,217

Table 5.1.9 Comparison of Steam Intensity by Season

	Olvit	Excellent factory	Production in Olvit
Winter	4,601 MJ/t	1,629 MJ/t	4,275 t
Summer	2,046 MJ/t	1,222 MJ/t	4,370 t
Annual average	3,125 MJ/t	1,425 MJ/t	4,488 t

Steam intensity in winter at Olvit : Average in January, February, March, and December

Steam intensity in summer at Olvit: Average in May, June, July, and August

(2)-2 Difference due to technical factors

Energy conservation potential is divided into the following three steps to sort out its potential.

Step 1: Enhancing the management
Step 2: Improving the equipment
Step 3: Improving the processes

a. Process

1) Deodorizer

① Design capacity and production

Present design capacity of De smet: 370 t/d
Actual production: 158.2 t/d (as of September, 1997)

Design capacity of De smet: 250 t/d
Design capacity of Krupp:
No. 1 150 t/d: Often shut down recently.
No. 2 120 t/d
No. 3 250 t/d: Shut down when De smet is provided.

The operation rate is as low as 50 % or less of the design capacity. It can be presumed that heat radiation from the entire factory is relatively large due to the low operation rate. For the actual production amount, 53,858 t, in 1996, a 3 % or more heat radiation loss is estimated in the total steam heat for processes.

Continuous operation of De smet and operation improvement through batch production, etc. allow radiation heat loss to be reduced. The inprovement of the energy intensity (MJ/t) that can be achieved by decreasing the heat radiation loss is as follows:

Steam intensity by processes is 2,205 MJ/t; Refine process consumes 5 MW of process steam 9.5 MW.
Therefore the following equation is obtained.
$2,205 \times 5/9.5 \times 0.03 = 35$ MJ/t (1,885 GJ/y)

② Heat exchanging between the treated refined oil and raw vegetable oil

Normally, the treated oil of 260 °C that is deodorized on the tray in the deodorizing tower is heat-exchanged with the bleached oil in the tower for cooling, heat-exchanged with the neutralized oil outside the tower, and then cooled by water outside the tower.

Although the new De Smet type deodorizing tower uses heat generated through heat exchange between the deodorized oil and bleached oil outside the tower, the Krupp type deodorizing tower does not have the heat exchanger for the raw oil.

The specified temperature at the refining plant in the excellent factory is 90 °C for the neutralizing process, 105 °C for the bleaching process, and 260 °C for the deodorizing process. The temperature in the deodorizing process is highest, and after the deodorizing process, the finished product comes out after being cooled to 30 °C. During this cooling period, heat is recovered through a heat exchanger by using the raw oil, the neutralizing process oil, and deodorizing process oil whose temperature is lower than the temperature in the deodorizing process.

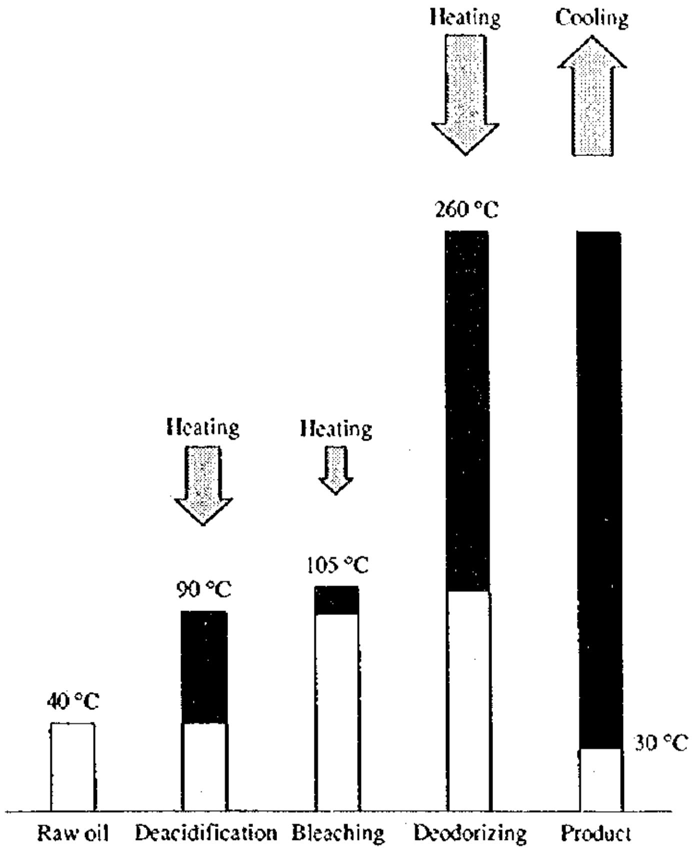
Figure 5.1.6 shows the temperature for each porcess in the excellent factory.

Steam consumption by one of two lines in the neutralizing process can be reduced by 20 % by recovering exhaust heat from the lines of the Krupp type deodorizer.

Figure 5.1.5 shows steam consumption for raw oil (2.5 MW) and refining (5 MW). Steam consumption of one line of Krupp system is 3.75 MW (= 2.5 MW + 1.25 MW) including steam use for space heating. Energy intensity of the Krupp system is 1,148 MJ/t (= 2,940 MJ/t × 3.75/9.6), in which 2,940 MJ/t is the factory energy intensity. When refined oil of the Krupp system is heat-exchanged with an efficiency of 60 %, the following eneryg conservation will be expected:

1,148 MJ/t × 0.6 = 689 MJ/t

Figure 5.1.6 Temperature Reference for the Oil Refining Process



In this factory, however, the equipment load is as low as 50 % or less, causing a large amont of loss in the neutralizing process and the deodorized oil storage tank. Thus, the heat recovery effect, which may not be achieved as that theoretically calculated, will probably remain as low as around 20 % of the calculated value.

689 MJ/t × 0.20 = 138 MJ/t (7,432 GJ/y)

③ Vacuum adjustment

Figure 5.1.5 shows steam consumption as given below.

Steam CHP 11 MW	Process steam 9.6 MW	Raw vegetable oil	2.5 MW
		Refining	5.0 MW
		Hardening	1.0 MW
		Margarine	1.1 MW
Space heating 1.4 MW			

Generally, refining (5.0 MW) can be divided into 2.5 MW in the neutralizing/bleaching process and 2.5 MW in the deodorizing process.

If 22 % of the steam intensity (2,940 MJ/t) shown in Table 5.1.6 is steam for the ejector, 646 MJ/t is used to generate vacuum in the deodorizer.

At the point of this study, the deodorizing condition of this company was 3 Torr in terms of vacuum, while in the excellent factory the vacuum is 6 to 8 Torr in the hardened oil plant.

The energy conservation potential achieved by reducing the vacuum degree during deodorization by approximately 6 Torr is expected to be significantly large.

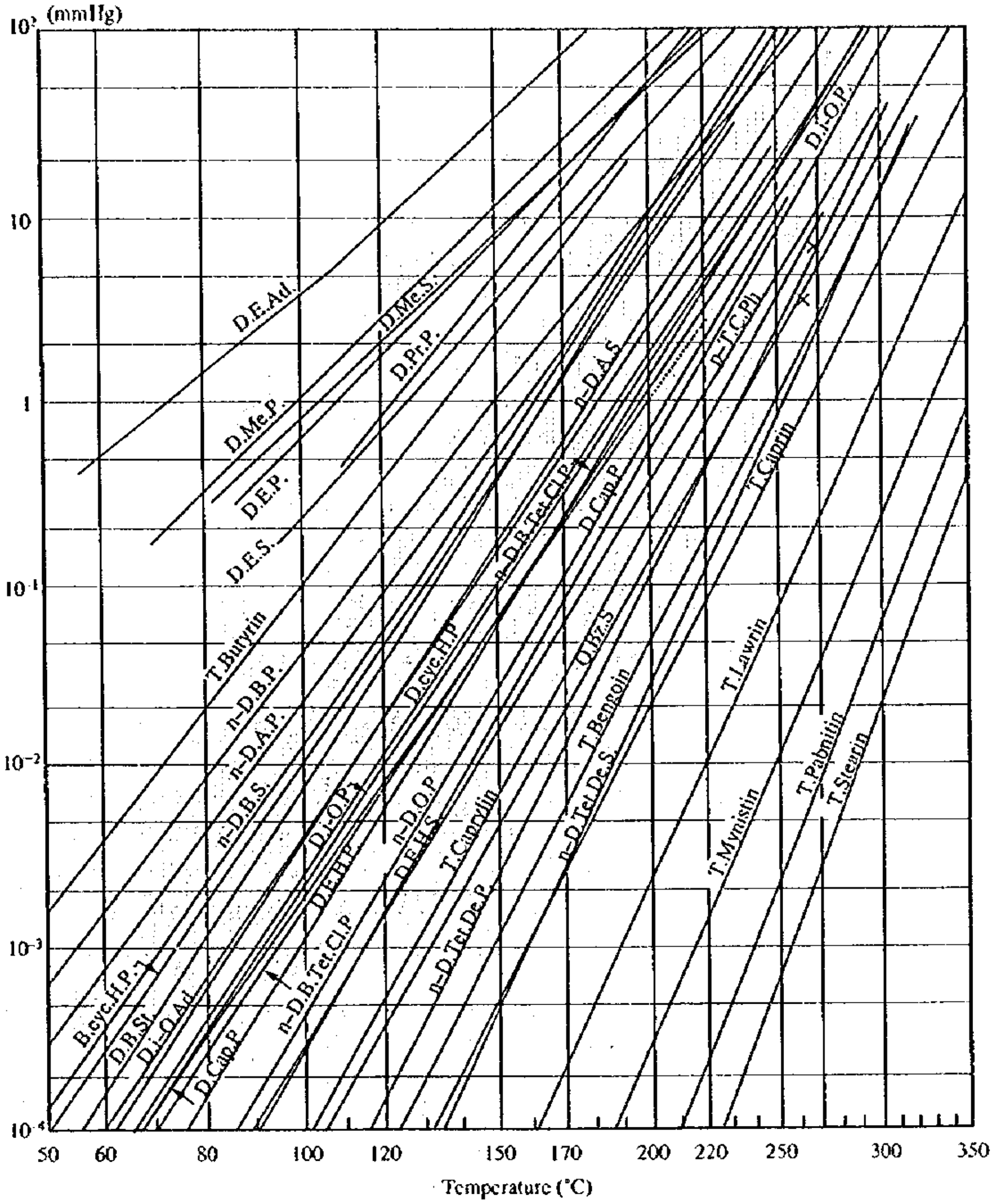
The design condition at Olvit is deodorization at a vacuum degree of 4 Torr using 10 kg/cm² steam on the ejector in the deodorizer tower. In the excellent factory, deodorization at a vacuum degree of 6 to 8 Torr using 7 kg/cm² steam is being performed. By reducing the vacuum degree to 6 to 8 Torr, the steam consumption by the ejector will be below a half.

According to Figure 5.1.7, most odorant substances (both esters and hydrocarbons) are removed at the same time at 260 °C and 3 mmHg (Torr), and at 265 °C and 8 mmHg (Torr).

Coloring caused by the temperature rise of 5 °C can be ignored and it will not pose a quality problem. The steam consumption by a steam ejector differs greatly between the vacuum 3 Torr and 6 Torr. If the vacuum degree is reduced from 3 Torr to 6 Torr, steam used by the steam ejector can be theoretically saved by 70 %.

The consequent improvement of the energy intensity is shown in ④.

Figure 5.1.7 Vapor Pressure of Organic Compounds (Esters)



Symbols:

A.	Amyl	D.	Di	P.	Phthalate
Ad.	Adipate	E.	Ethyl	Ph.	Phosphate
B.	Butyl	H.	Hexyl	S.	Sebacate
Bg.	Benzyl	i-	iso-	St.	Stearate
C.	Cresyl	Me.	Methyl	T.	Tri
Cap.	Capryl	n-	normal	Tet.	Tetra
cyc.	cyclo	O.	Octyl		

④ Ejector steam pressure

Presently, 10 kg/cm^2 (G) steam is in use, while in excellent factory, 7 kg/cm^2 (G) steam is in use. For ejectors, which are generally over-designed in most cases, efforts should be made to minimize air leak, and then a test should be carried out for gradually reducing the steam pressure while the vacuum degree is being monitored.

There is a past example in which the steam flow rate was reduced by approximately 30 % when the steam pressure was decreased from 10 kg/cm^2 (G) to 7 kg/cm^2 (G).

For calculation of the energy conservation potential, if the effect is considered to be 50 % practically when ③ is included, the improvement in the steam intensity will be as shown below:

Improvement in the steam intensity: 646 MJ/t × 0.5 = 323 MJ/t (17,396 GJ/y)

2) Hydrogenation reactor

① Reduction in the reaction time

The excellent factory adopts the Swiss BUS type batch reactor that removes the mixture of hydrogen and oil/grease from the top of the reactor to the outside of the reactor via piping and then blows the mixture back to the bottom of the reactor. The reaction time is approximately 1/4 of that for the Olvit 6-hour cycle system. Heat radiation is reduced and steam consumption becomes around 30 % of that by the conventional equipment.

In the steam intensity (2,940 MJ/t) shown in Table 5.1.6, if 9 % is assumed to be steam for hardening according to Figure 5.1.5, 265 MJ/t is used by the reactor. Therefore, by adopting the BUS method, the steam intensity can be improved by the following amount:

265 × 0.7 = 186 MJ/t (10,018 GJ/y)

② Recovery of exhaust heat from cooling water for the hydrogenation reactor

In the reactor, the raw vegetable oil is heated to 200 °C, which is held at that temperature for a certain period until reaction is completed. Then, cold water is fed to the heat exchanger to let the temperature of the oil go down to 100 °C once and then heating to 240 to 260 °C is applied in the deodorization tower.

At Olvit, hot exhaust water from the heat exchanger is not recovered. Methods such as recovering the hot exhaust water to the hot water tank to use it for preheating the feedwater to the boiler should be considered.

3) Filtering equipment

① Automation of post-bleaching filtering machine

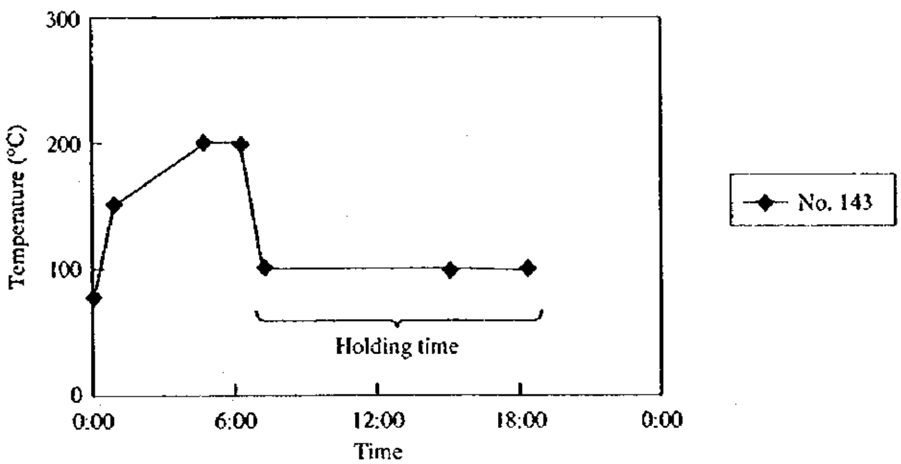
The forced filtering machine used after the bleaching process is said to be the bottleneck in the production capacity. As it is now under consideration at Olvit, the filtering machine currently in use should be replaced with an automation machine.

② Maintenance of hydrogenated oil filtering machine

Maintenance of the filter after the hydroganation process (i.e. reactor) is also necessary. An extremely large amount of heat loss from the surface and labor is required for the forced filtering machine. The heat loss detected on the discharging side tray is considerably large. Presently, two of five reactors are in service, presenting the operation rate of 50 % or below. The filtering process after the reactor constitutes a bottleneck. An example is seen that the reactor stores oil even after hydrogenation is finished. Therefore, the heat radiation loss is large although heat insulation is applied. As mentioned later, in this process, a 5 % heat radiation loss is estimated.

Figure 5.1.8 shows the status in which the hardened oil that passed through reaction still remains in the reactor due to faulty filter maintenance in the subsequent process although reaction on the reactor is completed.

Figure 5.1.8 Hydrogenation Cycle Pattern



Hardened oil production: 49,928 t × 0.5 = 24,964 t
Specific heat : 0.5
Holding time : 10 hours
Heat insulation : Maintained at 100 °C, 1 °C/h down

24,964 × 4.186 MJ × 0.5 × 10 h = 522,500 MJ/y

522,500 MJ/53,858 = 9.7 MJ/t

For the present hardening steam (265 MJ/t) described in "2.① Reduction in the reaction time", the heat radiation loss is as shown below:

9.7/265 × 100 = 3.7 %

Additionally, supposing a heat radiation loss of 1.3 % (estimated) to be caused by the waiting time of the filtering process, heat radiation is equivalent to approximately 5 % of the hardening steam as described earlier.

By making efforts for maintenance of the filtering machine so that an annual production of 60,000 t can be achieved, the hardening steam can be saved by at least 2 %.

Reduction in the steam intensity: 265 MJ/t × 0.02 = 5.3 MJ/t (285 GJ/y)

4) Yield improvement

Among several kinds of margarine products of this factory, a product with 30 % water is popular. In excellent factory as well, milk-blended neo-margarine with 40 % water enjoys popularity because it lasts long and is resistant to oxidizing.

For margarine, also the yield differs depending on the quality. Thus, improving yield through future product developent and research is important, and this also leads to improvement of the energy intensity. Therefore it is advisable to pursue positive research and development.

b. Utilities (heat utilization facility)

1) Measurement and analysis of components in the boiler exhaust gas

This factory uses much steam for the food oil production processes, heat insulation of the tank, heating, etc. This steam is purchased from an adjacent centralized steam supplier via piping. For the boiler of this factory, only a small package boiler using heavy oil is provided for the De smet type process. Figure 5.1.9 shows the result of measuring oxygen content in the exhaust gas from this boiler.

Figure 5.1.9 Measurement of Exhaust Gas from the Boiler for De smet

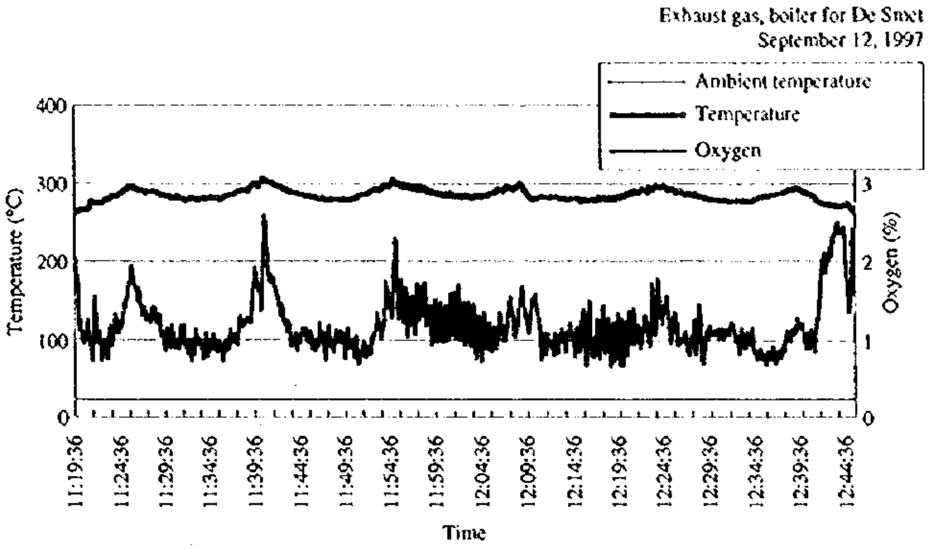


Table 5.1.10 shows the result of combustion calculation using the average of the measured values provided in this measurement period. This table also shows the result of measurement with the measuring equipment made by TESTO in Germany carried by the consultant who attended the visit to this factory. There seems to be no difference between both measured values.

Table 5.1.10 De Smet Boiler Combustion Calculation

Preconditions

Coal	Heavy oil (Class A)	
	Net heat value (kJ/kg)	42,965
	Net heat value (kcal/kg)	10,262
Air temperature		24.1
Exhaust gas temperature		285.3

Note: Measurement was conducted at the entrance of the boiler.

Calculation Result

	Theoretical Combustion	Data Measured by ECC	Data Measured by TESTO
Exhaust gas oxygen	0.0 %	1.19 %	1.30 %
Air ratio	1.00	1.06	1.06
Air flow rate (m^3/kg)	10.8	11.4	11.5
Exhaust gas volume (m^3/kg)	11.5	12.1	12.1
Exhaust gas loss rate (to combustion heat)		10.5 %	9.9 %

Note: TESTO means the measuring equipment carried by the consultant.

According to this measurement, oxygen content in the exhaust gas is ideally low and the air ratio is about 1.1, which is better than 1.3, the standard value in excellent factory. The exhaust gas temperature is slightly higher than 250 °C which is the standard value in excellent factory. According to these conditions, the heat loss of the exhaust gas is calculated to be approximately 10 %. Therefore, the boiler efficiency is considered to be 85 to 90 %. Table 5.1.11 shows the specifications of the boiler measured.

Table 5.1.11 Boiler Specificaition for De Smet

Item	Dasign Value	Remarks
Manufacturer	Geka Warmetechnik	Kahlsruhe Germany
Type	NUK HP100	
Model	Small-sized once-through boiler	
Evaporation	3,475 kg/h	
Pressure temperature	7.5 bar × 291 °C	
Heating area	62.5 m^2	
Water retention	478 L	
Heat output	1,455 kW	

2) Energy conservation by reinforcement of heat insulation

In this factory, valves in the steam piping line are not provided with heat insulation, whereas most valves in the steam receiving station are provided with heat insulation. Table 5.1.12 shows the result of heat radiation calculation based on the assumed number of valves to grasp the heat radiation from these valves.

If heat insulation is applied to the steam valves, heat radiation loss can be reduced to approximately 10 %.
Operation time: 6,720 h/y
Steam saving : 745,835 × 0.9 × 6,720/1,000,000 = 4,511 GJ/y

Table 5.1.12 Heat Radiation from Valves not Provided with Heat Insulation

Nominal Diameter (mm)	Equivalent Length (m)	No. of Valves Installed (Assumed)	Heat Radiation (kcal/h)	Heat Radiation (kJ/h)	Equivalent Steam (kg/h)
25	1.22	300	57,697	241,567	96
40	1.11	200	50,025	209,444	83
50	1.11	100	31,137	130,364	52
80	1.25	50	25,820	108,120	43
100	1.27	20	13,461	56,358	22
Total			178,140	745,835	297

Preconditions for calculation: Room temperature: 32 °C
Valve surface temperature: 140 °C
Steam heat value: 600 kcal/kg = 2,512 kJ/kg

Table 5.1.13 shows the result of calculation using the autoclave on the hydrogenation unit to know heat radiation from the surfaces of the tank, etc.

Table 5.1.13 Heat Radiation from Hydrogenation Unit Autoclave Surface

Room Temperature (°C)	Surface Temperature (°C)	Surface Area (m^2)	Unit Heat Value ($kcal/m^2/h$)	Heat Loss (kcal/h)	Heat Loss (kJ/h)	Equivalent Steam (kg/h)
32	50	49	115	5,631	23,574	9

Preconditions for the surface area: 2.5 mD × 5 mH × 5 sets
Assuming the surface temperature to be 70 °C, the heat loss will be 52,209 kJ/h.

If heat insulation is applied to the 5 sets of autoclaves, heat radiation can be reduced to approximately 10 %.
Operation time: 6,720 h/y
Steam saving : 23,574 × 0.9 × 6,720 × 5 = 715 GJ/y

In this factory, there are numerous heat radiating surfaces such as those on various indoor units and outdoor tanks. Heat insulation to some of them is not satisfactory. Since these surface areas are large, the damaged heat insulation portion should be repaired.

3) Measurement of the steam trap

This factory uses many steam traps. It is impossible to know from the outside whether the steam trap is operating normally. In this audit, we carried the measuring equipment for inspection of the steam trap operation. To use this measuring equipment, the sensor is made to contact the outer surface of the steam trap and the operation status of the steam trap is patterned and indicated according to the temperature, ultrasonic wave, etc. Table 5.1.14 shows the result of measuring several steam traps in this factory. As shown in this table, some traps are not normally operating; thus it is advisable to measure all traps on a regular basis.

Table 5.1.14 An Example of Measurement with a Steam Trap Checker

Equipment	Trap Position	Readings on the Checker
Hydrogenation equipment	0.2 MPa line at the bottom of the square tank	Clogging, 123/109 °C
Hydrogenation equipment	1.5 MPa line at the bottom of the autoclave	152/109 °C
Krupp type deodorizer	Lower part 1.2 MPa line	Stays ON, 165/95 °C
De Smet type deodorizer	Lower part	Normal

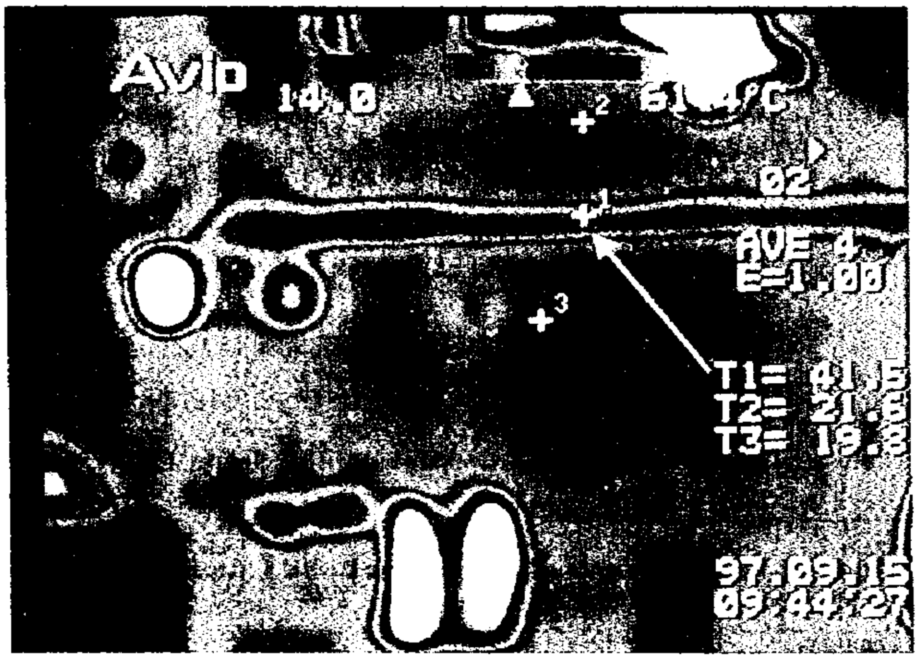
4) Enhancement of condensate recovery

In this factory, condensate recovery after the steam is used is not satisfactory. Some condensate is not recovered but discharged into the drainage way. Also, the condensate led to the recovery tank does not seem to be reused but discharged. Clean condensate should be separated from dirty condensate to provide the recovery line. Whether the condensate heat only is to be used or the water is also to be used must be examined.

5) Observation using the infrared thermal imaging system

If the infrared thermal imaging system is used, temperature distribution on equipment and steam piping can be recorded as images. Therefore, the heat insulation status can be visually identified. Figure 5.1.10 shows the image of the autoclave on the hydrogenation unit recorded in this factory. The inadequately insulated portion that cannot be known from the outside can be identified.

Figure 5.1.10 Infrared Thermal Image of the Autoclave No.2 Upper Part

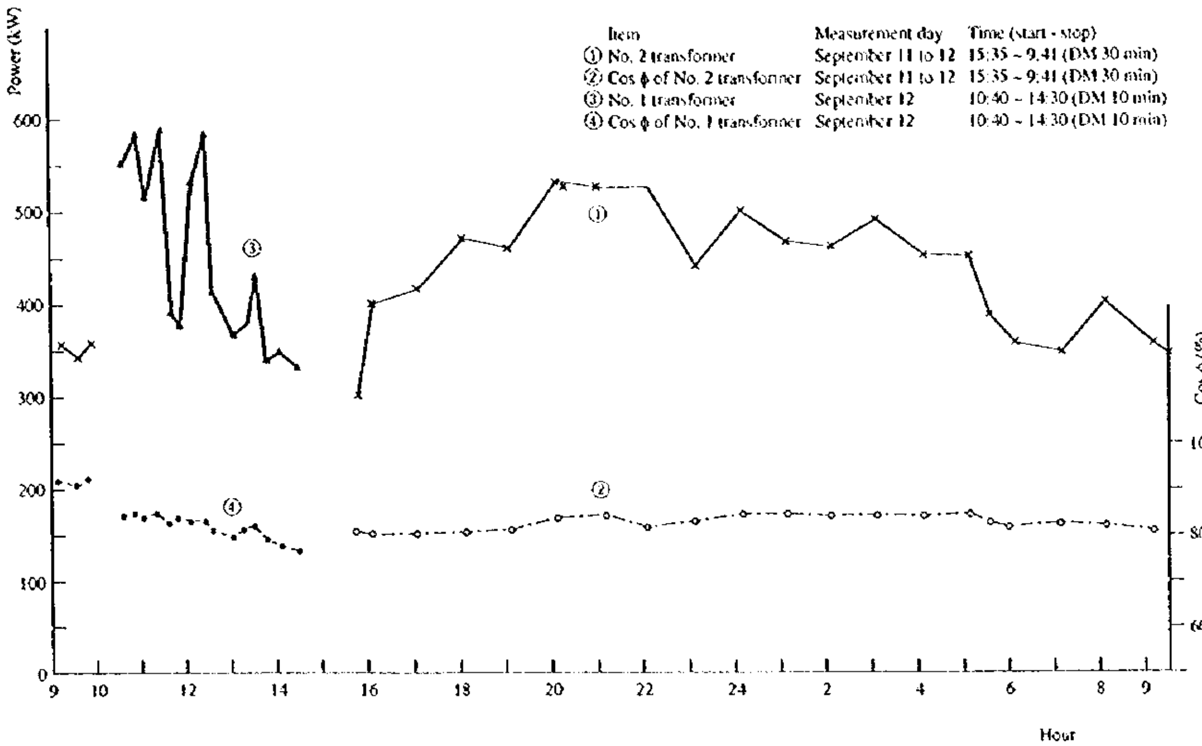


c. Utilities (electricity utilization facility)

1) Peak electricity suppression and power factor improvement

As a result of continuous measurement, electricity consumption of the factory was 370 to 570 kW for the No. 1 transformer and 320 to 600 kW for the No. 2 transformer. Additionally, the electrolytic plant uses approximately 1,000 kW. Among them, the load of the No. 2 transformer tends to reach the peak and the power factor is low as shown in Figure 5.1.11. Therefore, the following measures are required:

Figure 5.1.11 Operation Record of Electricity Power Consumption



Recommendable measure:

① The demand monitoring equipment should be installed to suppress the peak electricity according to the alarm for demand control.

② To reduce the peak electricity, adjustment such as staggering the starting or operating time of major equipment with a large load should be attempted.

Effect:

Since peaks of electricity consumption do not overlap, the demand can be reduced and the contracted electricity can also be decreased depending on the situation.

Based on the fact that the average electricity consumption in 1996 was approximately 1,503 kW (= 10,070 MWh/6,700 h), the maximum electricity demand is usually presumed to be approximately 2,000 kW. Therefore, the present contracted electricity (2,900 kW) can be reduced to approximately 2,500 kW and approximately 36,000 PLN (= {(2,900 – 2,500) kW × 1.66 + (2,490 – 2,000) kW × 4.77} × 12 months) can be saved a year.

1.66 and 4.77: Unit price PLN/kW

Contract demand reduction: 400 kW (= 2,900 – 2,500)

2) Optimization of No. 2 transformer voltage and improvement of load power factor

The low-voltage side voltage of the No. 2 transformer is 404 V, which is slightly high. The load of this transformer accounts for only a part of the refining and margarine plants and the power factor is 60 %, which is low. Therefore, the following measures are considered to be necessary:

Recommendable measures:

① The secondary-side voltage of the transformer should be dropped to approximately 395 V.

② To improve the load power factor, a capacitor should be installed on the secondary side of the transformer or at the position of the motor with a low power factor. For the motor in the refining plant whose power factor is 70 % or below, take the latter measure. (See Table 5.1.15.)

Table 5.1.15 Measurement Data of Major Load

September 11, 12, 15, 1997

Transformer or Name of Load	Rating (kW)	Consumption (kW)	Voltage (V)	Power Factor (%)	Remark
Electolysis cell	3 x 450 kVA		924	140	2,200A DC by Board
No. 1 transformer Total	1,600	331 ~ 594*		77 ~ 85	Recording
Cooling fan margaine		133	396	81	
Pump	3 x 45	11	397	98	
Vacuum pump of refinery	2 x 37	32		72	
NH_3 compressor electricity	3 x 70	110	396	82	
Bottle and packing of oil		136	390	81	
Pump of cooling water	45 + 65 + 75	90	400	85	
		12	401	86	
H_2 compressor of electricity	45 + 37	40	393	77	
No. 2 transformer Total	1,600 kVA	308 ~ 537**		80 ~ 85	
Lighting	6 x 11	2	403		
Small motor of refinery		20	403	80	
Small motor of refinery		21	401	63	
Agitator of refinery	2 x 18.5	71	401	75	
Deodorization of oil (Crup, De Smec)	>70	97	401	76	
Air compressor of refinery	2 x 37	28	401	73	
Vacuum pump of refinery	2 x 37	48	401	87	
Gas cooling pump of refinery		2	401	61	
Separater of refinery	4 x 18.5	43	403	62	
Separater of refinery		37	404	57	
Mixer of margarine	3 x 30	53	403	61	

* Power of No. 1 transformer: AM 10:15 ~ PM 2:30, September 12

** Power of No. 2 transformer: PM 3:00, September 11 ~ AM 10:00, September 12

Effect:

The iron loss of the motor increases in proportion to a square of voltage. Therefore, if the motor is relatively light-loaded as in this factory, the voltage in use should be at the rated voltage or below to minimize the iron loss. This value is approximately 1 % to the entire load and considered to be approximately 33,000 kWh a year.

Electricity saving: 33 MWh/y

If the light-loaded motor is changed to a motor of the optimum capacitance, the power factor and efficiency will be improved, allowing electricity to be slightly saved. However, as mentioned in ② above, if the power factor is improved at each motor position, the electricity saving effect is large because the losses of the transformer and power line route are reduced but investment for the capacitor increases.

3) Measures for saving electricity used by the hydrogen plant

Presently, electricity used by the hydrogen generating plant is approximately 1,000 kW, which accounts for about a half of electricity used by the entire factory. The electricity intensity of this plant is as high as 186 kWh/t.

Therefore, saving of power consumption in this plant should be examined.

Measures:

① The water electrolysis conditions (e.g. water components, electrical resistance, voltage, current, etc.) should be surveyed and examined.

② Purchasing the hydrogen gas should also be examined.
If the hydrogen gas is regarded as a material whose power consumption is excluded, the electricity intensity will be improved to about a half.

③ Electricity consumption should be recorded in the plant's daily operation record to manage the amount of hydrogen generated, operation time, and electricity intensity.

Effects:

Electricity intensity improvement as a result of improving the water electrolysis conditions

Enhancing the on-side workers' understanding of intensity and improving their consciousness about electricity conservation.

4) Since improvement in the electricity intensity by separating the hydrogen plant as another company can be expected, the electricity intensity level will become equivalent to that of the excellent factory.

5) Chiller selection

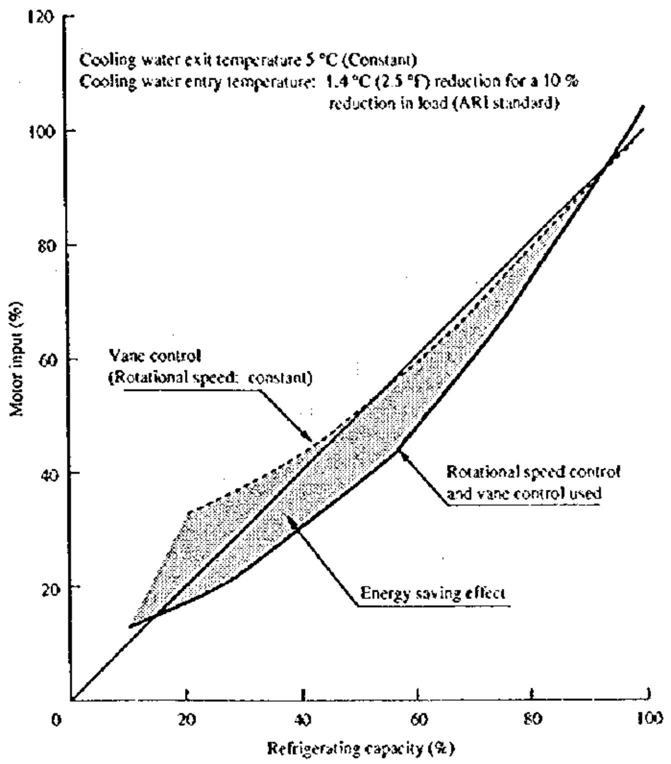
Olvit uses the ammonia type chiller, which is being deteriorated. Along with the recent enhancement of Freon regulation, the excellent factory examines the theoretically required electricity for various refrigerants and chilling cycles as shown in Table 5.1.16. Therefore, Olvit should investigate kW/USRT for the ammonia type chiller.

If the required electricity of the present ammonia type chiller is 1 kW/USRT and the inverter-driven turbo chiller is used, electricity consumption will be reduced as shown in Figure 5.1.9. Energy saving by approximately 30 % can be achieved, depending on conditions such as the operation time and load rate.

Table 5.1.16 Theoretically Required Electricity for Various Refrigerants and Chilling Cycles

Refrigerant	Molecular Formula	Theoretically Required Electricity (kW/USRT)			Operating Pressure (kg/cm^2abs)	
		Single-stage Cycle	Sub-cool Cycle	Economizer Cycle	0 °C	40 °C
R-11	CCl_3F	0.578	0.569	0.550	0.41	1.77
R-12	CCl_2F_2	0.625	0.599	0.581	3.15	9.80
R-22	$CHClF_2$	0.635	0.608	0.591	5.24	15.6
R-500	CCl_2F_2/CH_3CHF_2 (R-12/R-152a)	0.674	0.648	0.643	3.70	11.6

Figure 5.1.12 Energy Saving Effect of Variable Speed Control of Tube Chiller



(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 5.1.17.

Table 5.1.17 Emission Improvement by Energy Conservation Measures

Measure	Reduction [ton/year]			
	CO_2	SO_2	NO_2	Dust
Step 0				
Step 1	1,404	2.7	2.3	0.0
Step 2	471	0.9	0.8	0.0
Step 3	0	0.0	0.0	0.0
Step 1-3	1,874	3.6	3.0	0.1

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 5.1.18. Furthermore, the payback period 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 5.1.18 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	672	1.7	673	0	0.00	0.00
Step 2	434	0.6	434	685	1.58	1.58
Step 3	341	0.0	341	429	1.26	1.26
Step 1-3	1,446	2.3	1,449	1,114	0.77	0.77

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

As evident from this Table 5.1.18, 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 payback period is also negligible.

Since this factory purchases a major portion of steam from an outside source, energy conservation through the reduction of steam does not lead to a reduction in the pollutant emission fee. Consequently, a reduction in the pollutant emission fee does not improve the payback period.

b. Summary of Energy Conservation Potential

The energy conservation potential of this factory is shown in Table 5.1.19.

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 5.1.13. The relationship between energy conservation potential, the payback period, and the investment cost is shown in Figure 5.1.14.

Table 5.1.19 Summary of Energy Conservation Potential

Steam: 0.097 PLN/kg (2.85 GJ/t) Electricity: 0.172 PLN/kWh 1 PLN = 30 yen

Item		Energy Conservation Potential							Investment	Payback period
		Fuel			Electricity			Total		
		GJ/y	10^3 PLN/y	%	MWh/y	10^3 PLN/y	%	10^3 PLN/y	10^3 PLN	year
Step 1										
1. Reducing the heat loss from the deodorizer	St	1,885	64	1.1				64	0	0.0
2. Adjusting the deodorizer vacuum and ejector pressure	St	17,396	592	10.0				592	0	0.0
3. Improving the hydrogenation filters	St	285	10	0.2				10	0	0.0
4. Optimizing the transformer voltage					33	6	0.3	6	0	0.0
Subtotal		19,566	666	11.3	33	6	0.3	672	0	0.0
Step 2										
5. Reviewing the heating method of the deodorizer	St	6,463	220	3.7				220	314	1.4
6. Insulating the steam valves	St	4,511	154	2.6				154	208	1.4
7. Insulating tanks, etc.	St	715	24	0.4				24	150	6.2
8. Reducing peak power damand					400 kW	36		36	13	0.3
Total		11,689	398	6.7	0	36	0	434	685	9.3
Step 3										
9. Reducing the reaction time of the hydrogenation reactor		10,018	341	5.8				341	429	1.3
Subtotal		10,018	341	5.8				341	429	1.3
Total		41,273	1,405	23.8	33	42	0.3	1,446	1,114	0.8

As of 1996: Fuel consumption: 173,404 GJ/y
Power consumption: 10,070 MWh/y (103,278 GJ/y)
Total: 276,682 GJ/y

Figure 5.1.13 OLVIT Energy Conservation Potential

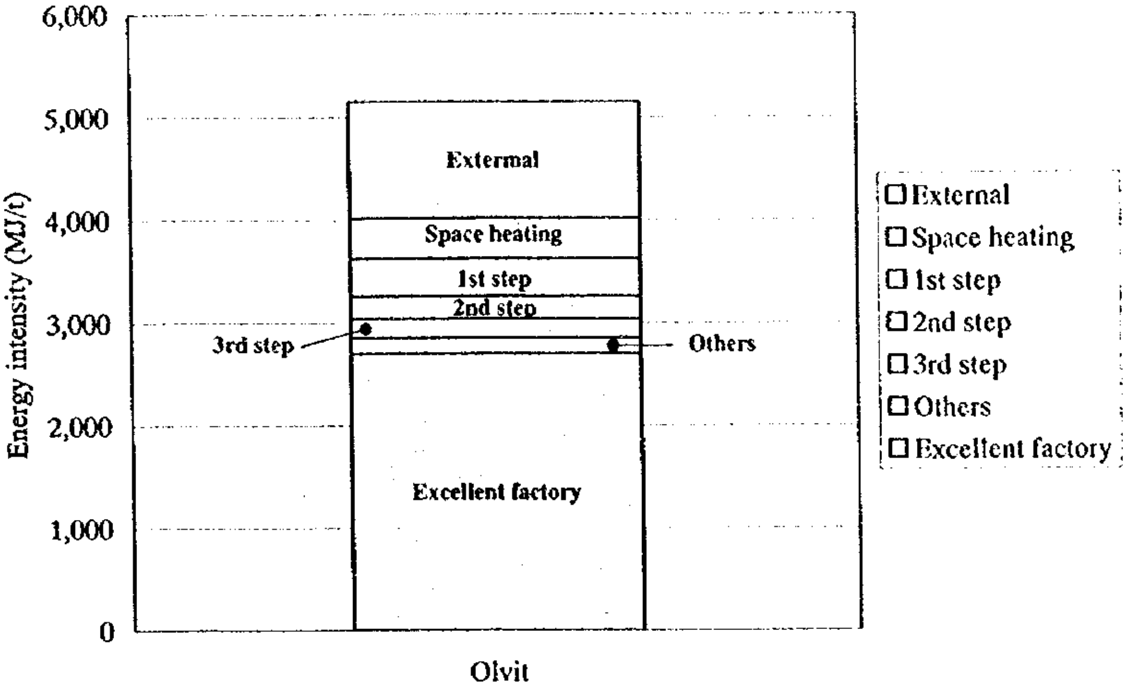
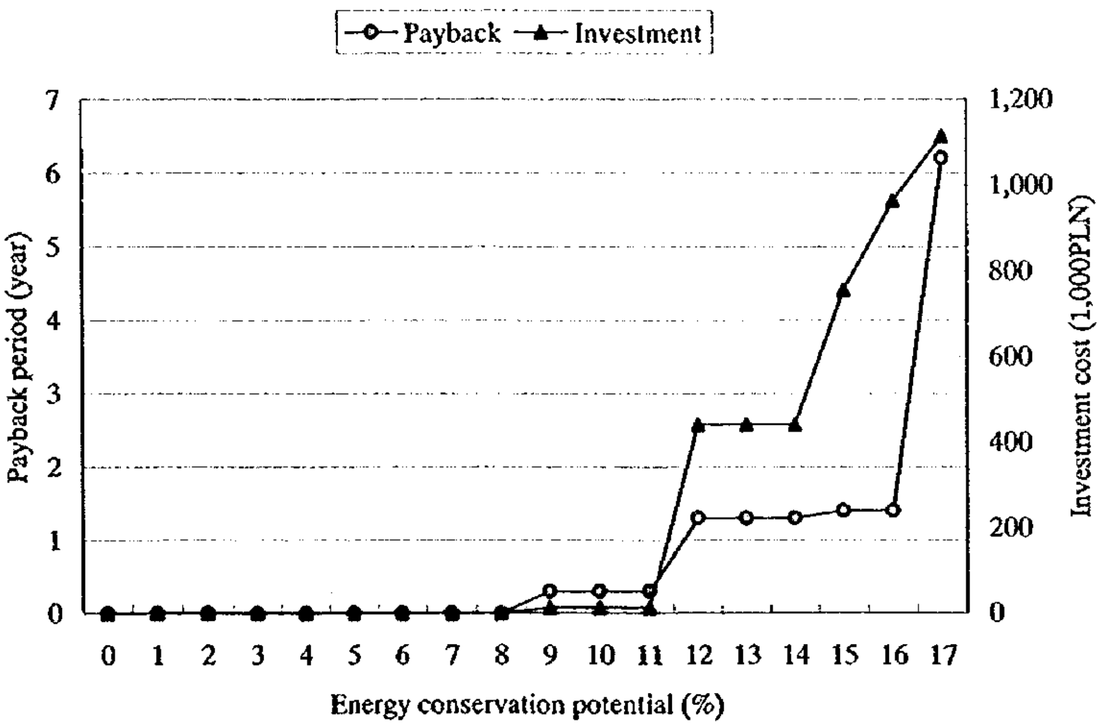


Figure 5.1.14 OLVIT Energy Conservation Potential



5.2 Results of the Study at the Koscian Meat Plant

(1) Study period: September 3 and 4, 1997

(2) Members of the study team

a. JICA Team

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

b. Local consultants

Research Center of Warsaw University of Technology
Dr. Krzysztof Wojdyga : Heat management
Mr. Maciej Chorzelski : Heat management
Mr. Stanislaw Kozinski : Electricity management

(3) Interviewees

Mgr inz. Ryszard Bereszynski: Director of Technology
Mgr inz. Maciej Przybyla : Energy Manager
Mr. Szarwark : Electrical Section
Mr. Tulinski : Electrical Section

5.2.1 Profile of the Plant

(1) Plant name: Zaklady Miesne, Koscian (Koscian Meat)

(2) Plant address: Koscian, ul, Svenkiewicza 22, Poland

(3) No. of employees: 505 (1996: 542)

(4) Major products: Meat, and ham/sausage

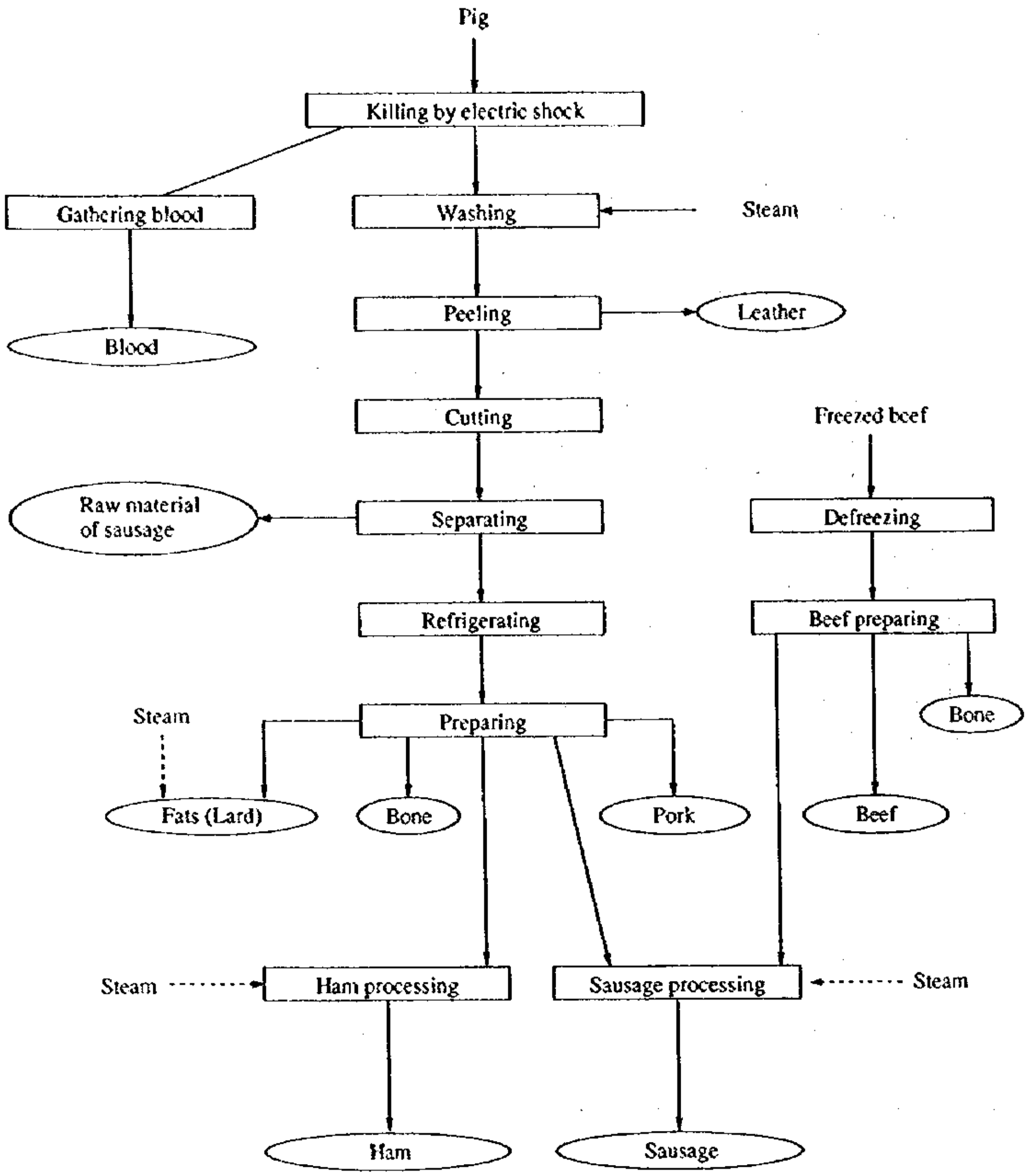
(5) Production capacity: 70 t/d

(6) Overview of process

After electric shock is applied to a pig, the blood is removed and the pig body is washed with hot water. Then, its skin is peeled off and the body is divided into two segments, which are put in the chilled room to be subjected to processing for ham/sausage. Separately, products are shipped also as carcasses.

The materials are mainly pigs. Frozen beef is mixed (30 %) and processed to produce ham/sausage. Figure 5.2.1 shows the process flow. Steam is supplied from the boiler in this factory.

Figure 5.2.1 Process Flow

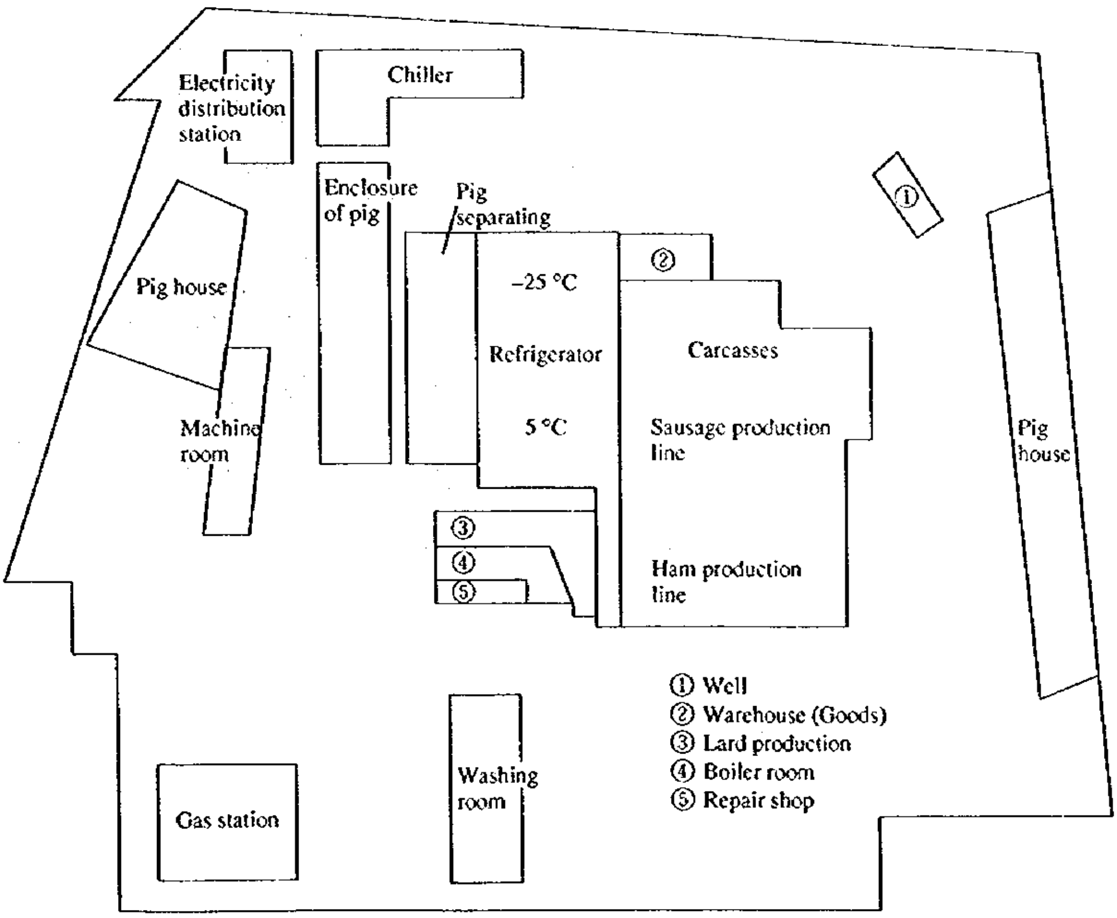


(7) History of the plant

This plant, which was founded in 1912, was nationalized after the World War II, and then in 1991, it had the operation transferred to a stockholding company, and thus was privatized. The stocks are owned by the state (25 %), secondary national investment fund (60 %), and company employees (15 %). This company is calling for strategic investment plans. Since summer in 1997, the beef factory in Lecino became a limited responsibility company whose factory is 100 % owned by Koscian Meat, which receives beef manufactured by Lecino. The company has 12 own retail shops as the bases for sales. In the past, most products were delivered to the Soviet Union. Although facilities that are capable of butchering up to 1,000 pigs a day are provided, 340 pigs are currently treated. Since the chiller has been deteriorated, another chiller is now under installation. It is now under consideration to introduce a vacuum packing machine made in Japan in the sausage process in order to speed up packaging three times faster. Under the present circumstances where the equipment are operating for production at only 30 % of their full capacity, restructure including personnel reduction is currently under planning. Presently, two-shift work system is employed, and production lines are shut down on saturdays and sundays.

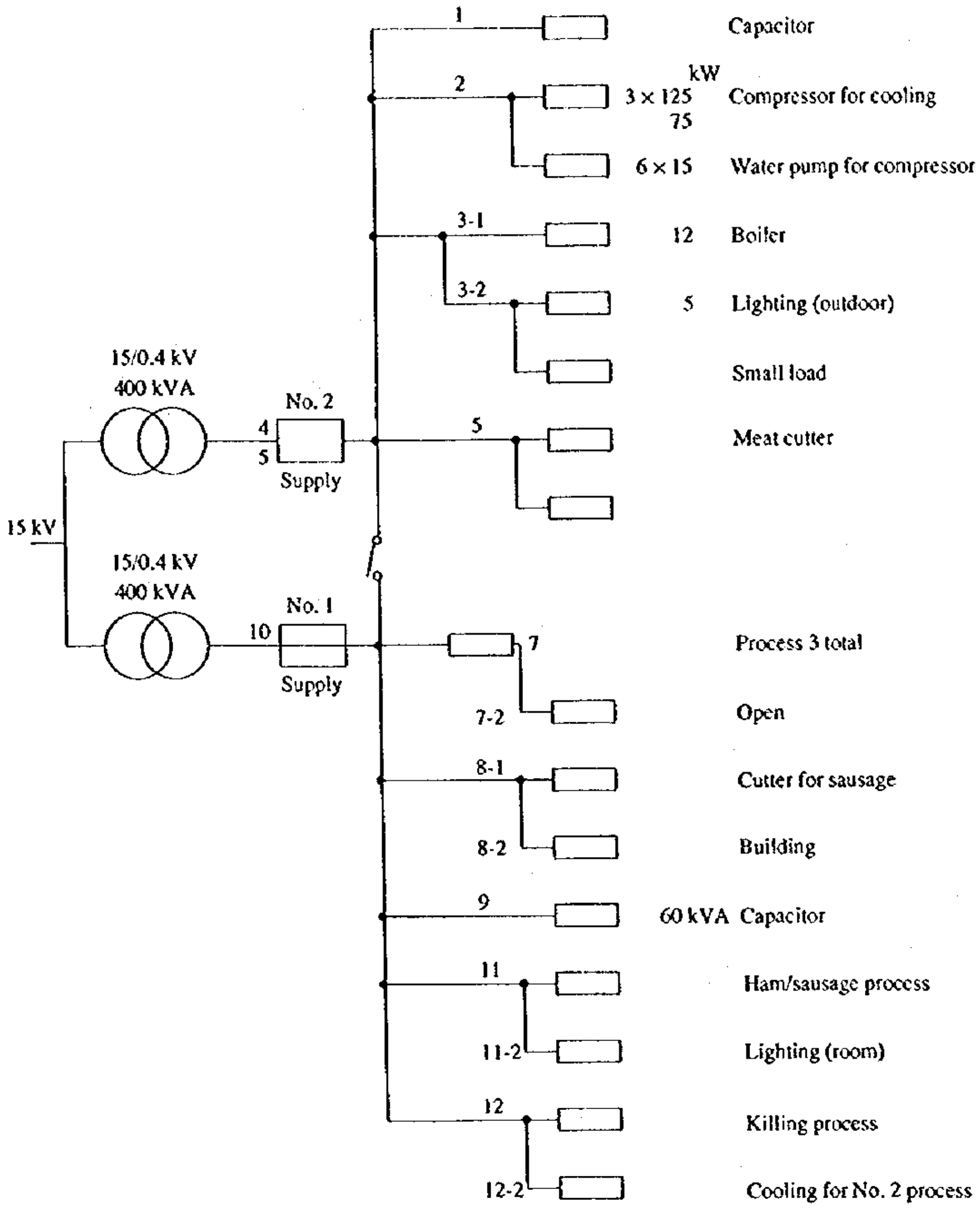
(8) Plant layout

Figure 5.2.2 Plant Layout



(9) One line diagram

Figure 5.2.3 One Line Diagram



(10) Outline of major equipment

Table 5.2.1 Major Equipement

Factory	Number	Specification
Process		
Pig washing bath	1	5 m³ 70 °C
Treatment machine	1	70 t/d 11 t/h
Chiller	3	125 kW × 3, 4 °C NH_3 type freezer
Ham packer	1	7.5 t/d, Automatic, made in Japan
Smoking room	10	600 kg/room 85 °C Steam
Chopper	2	20 t/d 90 kW + 80 kW
Cutter	1	12 t/d
Vacuum packer	1	1,200 packs/h 30 kW
Injector packer	1	4 kW 12 °C
Utility		
Boiler	2	4 t/h 0.13 MPa Natural gas
Water pump	6	15 kW for cooling
Air compressor	1	75 kW

(11) Energy price and heat value

Table 5.2.2 Energy Price and Heat Value

	Energy price	Heat value
Electricity	0.119 PLN/kWh	10.256 GJ/MWh
Natural gas	0.319 PLN/m³	28.80 GJ/m³
Coal	130 PLN/t	20,930 GJ/t

5.2.2 Energy Consumption Status

(1) Trend of energy consumption

Table 5.2.3 Trend of Production

(t/y)

	1992	1993	1994	1995	1996
Carcass products	9,113	7,948	5,874	6,276	5,698
Ham & sausages	1,546	1,745	2,020	2,469	2,210
Paste	348	492	510	588	614
Pork fats	1,413	1,234	1,122	737	668
Total	12,420	11,419	9,526	10,070	9,190

The production of carcasses is decreasing, while that of fatty products including ham, sausage and paste, is increasing. However, the entire production amount shows a tendency to decrease.

(2) Trend of energy consumption

Table 5.2.4 Trend of Energy Consumption

	Unit	1992	1993	1994	1995	1996
Natural gas	10^3 m^3	–	320	2,382	2,253	1,739
Coal	t	364.5	1,904	276	68	–
Electricity	MWh	2,549	2,466	2,367	2,234	2,650
Water	m^3	88,943	121,400	128,800	109,100	106,500

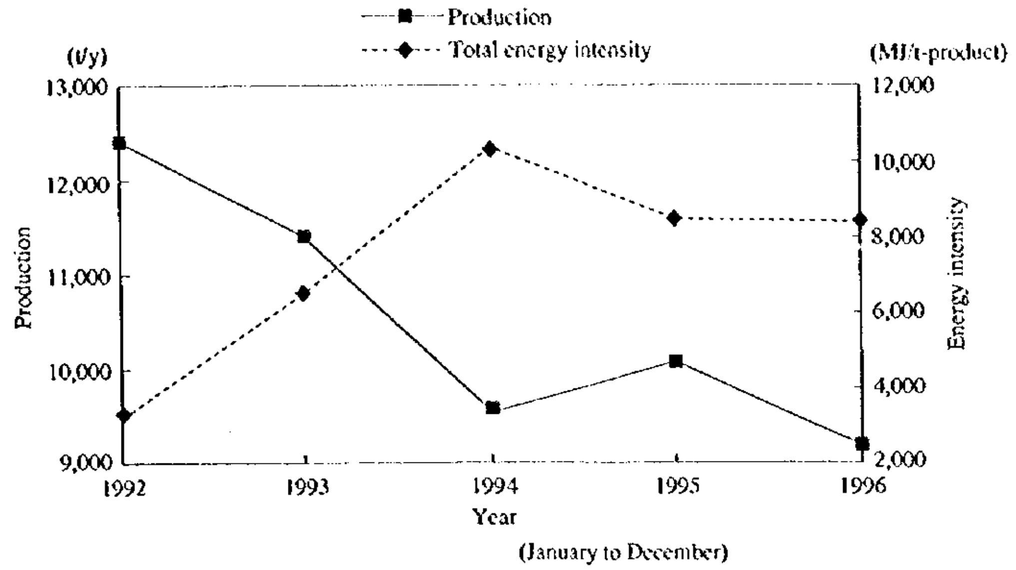
(3) Trend of energy consumption and intensity

As shown in Table 5.2.5 and Figure 5.2.4, the production amount is showing a tendency to decrease. Although in general energy intensity is likely to increase, total energy intensity shows a tendency to improve; however it cannot be said to stand at a satisfactroy level. The breakdown reveals that the energy intensity of the natural gas has reduced, and the electricity intensity rapidly increased in 1996, whereas it has decreased in the latter half of 1996.

Table 5.2.5 Trend of Energy Intensity

	Unit	1992	1993	1994	1995	1996
Consumption						
Natural gas	GJ	–	9,216	68,602	64,886	50,083
Coal	GJ	7,629	39,851	5,777	1,423	–
Electricity	GJ	26,143	25,291	24,276	22,912	27,178
Intensity						
Natural gas	MJ/t-product	–	807	7,203	6,433	5,450
Coal	MJ/t-product	614	3,490	606	141	–
Electricity	MJ/t-product	2,596	2,215	2,548	2,275	2,957
Total	MJ/t-product	3,210	6,512	10,357	8,449	8,407

Figure 5.2.4 Trend of Production and Total Energy Intensity

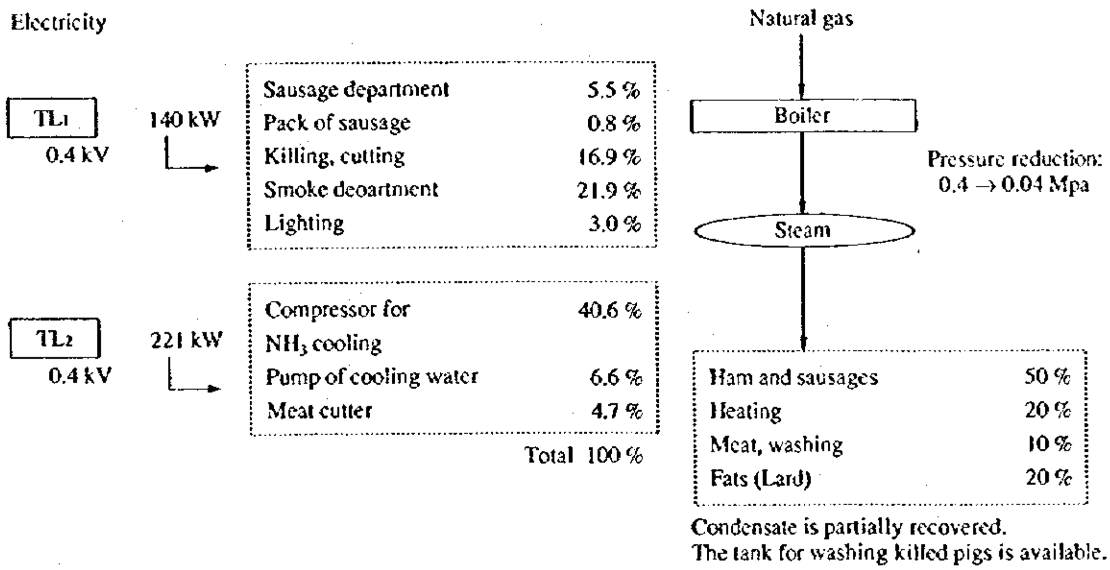


(4) Energy and material cost ratio to production cost

Material : 60 to 70 %
Natural gas: 1.3 %
Electricity : 0.3 %

(5) Energy flow

Figure 5.2.5 Energy Flow



(Note) The percentages were allocated based on the values measured on September 5, 1990. The percentages for steam, lighting and meat cutter are based on the data obtained through our investigation.

5.2.3 Energy Management Status

(1) Setting an energy conservation target

a. Setting the target value

No specific target value for energy conservation is set.

b. Problems in promotion of energy conservation

They are well aware of the necessity for collection of information as well as research & development, while at the same time they are faced with many problems in implementation of energy conservation, such as manpower shortage, lack of funds, inadequate analysis, shortage of measuring equipment and so on.

(2) Systematic activities

a. Installation of a dedicated section for energy conservation

The dedicated members are appointed but actually they have also another job, thus making their activities insufficient.

b. Installation of the energy conservation committee

The energy conservation committee is not provided.

c. Management stance

The management consider that the effects of energy conservation on the business are smaller than the material cost and thus they do not have much concern about energy conservation. Under the current situation where the production amount is decreasing, they are proceeding with a restructuring plan to reduce the number operators to 504 by the end of September, 1997 and to adopt an automatic packing machine made in Japan as a part of the plan.

(3) Data-based management

a. Grasping the energy used

Energy used by the entire factory has been recorded.

b. Grasping the energy used by each major facility

For energy conservation, it is important to keep track of the energy consumption by each major equipment. However, they have neither measurement example nor any correct understanding of energy consumption.

c. Grasping the energy intensity for major products

Energy consumption by product has neither been recorded, nor has the intensity been understood.

d. Installation of measuring equipment

The steam flow rate in the main line should be measured, for which purpose the measuring equipment need to be installed.

e. Production management and cost management

With the Lecino factory under their control, the materials for beef are separated for receiving, delivery, etc., whereas the cost management includes also that of the Recino factory, and not definitely divided, thus resulting in insufficient or inaccurate cost management. With few professional staff available, production control didn't be precisely performed.

(4) Plant engineering

They seem to be serious about improvement of facilities such as switching fuel of the boiler from coal to natural gas. It is praiseworthy that facility sanitation management is implemented as a matter of the first priority.

5.2.4 Problems and Measures related to Energy Use

(1) Comparison of the energy intensity with the excellent factory

Table 5.2.6 shows the result of comparing the energy intensity of Koscian Meat with that of the excellent factory. Also Table 5.2.7 shows the breaksown of energy intensities of the excellent factory. Since in Japan the butchery and carcass factory are separeted, the data in this table are calculated based on the data for the separate butchery and carcass factory and ham & sausage factory.

Table 5.2.6 Comparison of Energy Intensity

	Unit	Koscian Meat	Excellent Factory	Difference
Production	t	9,190	11,000	
Electricity intensity	MJ/t-product	2,957	2,704	243
Fuel intensity	MJ/t-product	5,450	1,524	3,926
Total		8,407	4,238	4,169

Table 5.2.7 Data of Excellent Factory

	Production	Energy intensity		Energy intensity [Integrated meat factory (Ham & sausage rate: 24 %)]	
		Fuel	Electricity	Fuel	Electricity
Butchery and carcass factory	24,353 t/y	844 MJ/t-product	2,272 MJ/t-product	844 MJ/t-product	2,272 MJ/t-product
Ham & sausage factory					
1) Raw meat storage	14,400 t/y		1,200 MJ/t-ham		0 MJ/t-product
2) Processing		2,832 MJ/t-ham	1,800 MJ/t-ham	680 MJ/t-product	432 MJ/t-product
Total	–	–	–	1,524 MJ/t-product	2,704 MJ/t-product

(2) Estimating the energy conservation potential

(2)-1 Difference due to external difference

Both Koscian Meat and the excellent factory produce meat mainly using pigs as raw material; therefore there is no difference due to raw materials and products.

Since Koscian Meat, which is located in the cold area, has a handicap (heat loss) in terms of climate condition, the difference in the fuel intensity is significantly large because of heating energy.

(Gas consumption)

1996 – 1997			
November	214,000 m^3_N		
December	231,000 m^3_N	Technology + Central heating	819,000 m^3_N
January	211,000 m^3_N		
February	163,000 m^3_N		
1997			
June	89,000 m^3_N		
July	100,000 m^3_N	Only to Technology	393,000 m^3_N
August	91,000 m^3_N		
September	113,000 m^3_N		

Considering that the production in winter is roughly 50 % larger than that in summer, the value is corrected as shown in the following equation. Thus the energy consumption for space heating can be estimated as follows.

$393{,}000 \times 1.5 = 589{,}500\ m^3_N$

Fuel used for heating: $819{,}000 - 598{,}500 = 229{,}500\ m^3_N$

Rate of fuel for heating: $229{,}000/819{,}000 \times 100 = 28.0\ \%$

At Koscian Meat, meat processing is controlled at 15 °C. In excellent factory, the workshop is managed at 12 °C because sanitation is considered important, and thus heating is provided to the office building only. Therefore, the difference in heating energy from the excellent factory is assumed to be an approximately 10 % heat radiation loss due to the temperature difference which is included in 28 % described above.

Even if heat radiation loss (10 %) is taken into consideration, the fuel intensity of Koscian Meat is 5,450 MJ/t × 0.9 = 4,905 MJ/t, which is 3.2 times worse than 1,524 MJ/t of the excellent factory.

The fuel intensity difference from the excellent factory, which is equivalent to heat radiation loss of 10 % as mentioned above, is as shown below:

5,450 MJ/t × 0.1 = 545 MJ/t

(2)-2 Difference due to technical factors

Energy conservation potential is divided into the following three steps to sort out its potential.

Step 1: Enhancing the management
Step 2: Improving the equipment
Step 3: Improving the processes

a. Process

1) Ham/sausage heating process

The filled ham/sausage is fed to the heating process. Ham/sausage filled in the well-permeable casing (e.g. natural gut, cellophane, etc.) is smoked and then boiled. Ham/sausage filled in the air-tight casing is fed to the boiling process to be boiled. The heating time is set so that heating will be performed at 70 to 80 °C and the center part will be heated to 63 °C for at least 30 minutes. Most smoke generators have been automated and their performance has been greatly improved. Therefore, smoking is performed for about 1/5 of the traditional smoking time but care must be taken to flavor. The excellent factory recovers about 60 % of the condensate from steam heating in addition to reducing the smoking time, which is considered to be a major factor making the intensity difference from Koscian Meat. The condensate recovery rate at Koscian Meat is estimated to be around 30 %.

As shown in Figure 5.2.5, 50 % heat energy is used to produce ham and sausage. Energy conservation of 10 % is expected to be possible if the condensate recovery rate is improved.

Improvement in the natural gas intensity:

5,450 MJ/t-product × 10 % = 545 MJ/t-product (5,008 GJ/y)

Further, energy conservation can be expected if the smoking time is reduced in the similar way as employed in the excellent factory.

2) Fresh-air intake

This factory, which is now proceeding with improvement of packing, should also give consideration to reinforcing of the heat-insulation and fresh-air intake for building air conditioning, etc. The excellent factory sterilizes and filters the fresh-air in winter and takes it into the workshop for air conditioning of the chilled room (4 °C) and reserved room (10 °C) to reduce the electricity load for the chiller.

On the other hand, Koscian Meat uses ammonia for the chiller, and therefore the air conditioner can have a wide space at the condenser side and efficiency seems to be good. Furthermore, as a means of improvement of the electricity intensity, the fresh-air intake air conditioning system is available. Although this requires further studies of the details, its feasibility is considered for about 20 % of the building area.

If 20 % of compressor electricity for NH_3 cooling (40.6 %) in Figure 5.2.5 is saved by the fresh-air intake system, the following improvement in the electricity intensity can be expected:

2,957 MJ/t-product × 0.406 × 1/5 = 240 MJ/t-product (215 MWh/y)

3) Installation of the curtain at the exit/entrance

For the room temperature in the meat processing factory, the butchery plant should be at 15 °C, the chilled room at 4 °C, and the processing room at 10 °C. In the lard plant, where the double cooker is used, air conditioning should be controlled by installing a curtain at the entrance/exit. If fresh-air is at a high temperature in summer, a curtain should be provided at the entrance/exit to prevent entry of fresh-air.

If the curtain is provided in this plant, it is expected that the energy intensity will be improved by approximately 1 %.

Improvement in the gas intensity	: 5,450 × 0.01 = 55 MJ/t-product (505 GJ/y)
Improvement in the electricity intensity:	2,957 × 0.01 = 30 MJ/t-product (27 MWh/y)
Energy intensity improvement	: 85 MJ/t-product

4) Yield improvement

Table 5.2.8 shows the breakdown of production and sales in 1996 and 1997.

Table 5.2.8 Production and Sales

Breakdown		Sales result (t) (1996)		Sales planned (t) (1997)
	Pork products	63 %		62 %
	Beef products	37 %		38 %
Pork	Pork carcass	1,100		1,180
	Pork blocks	1,172		730
	Chopped pork			220
	Haslet	334		197
	Lard	665	(Lard yield 11.5 %)	630
	Sausage/ham (Pork 70 %)	860		931
	Smoked ham (Pork 100 %)	956		730
	Paste	607		680
	Vacuum pack	0		540
	Sub-total	5,684		5,838
Beef	Beef carcass	1,331		1,450
	Beef blocks	1,005		153
	Chopped beef	0		965
	Pluck	302		338
	Beef tallow	235		50
	Suet	100	(Suet yield 10.0 %)	250
	Sausage/ham	368		399
	Sub-total	3,341		3,605
Total		9,025		9,443

Production amount : 9,190 t/y
Difference from sales: Loss of bones and skull – 165 t/y (1.8 %)
Stock included
Yield : $9{,}025/9{,}190 \times 100 = 98.2$ %

The yield is 98.2 %, which is considered to be fairly good.

Since sales management is performed well, continuous maintenance/improvement of the yield is expected.

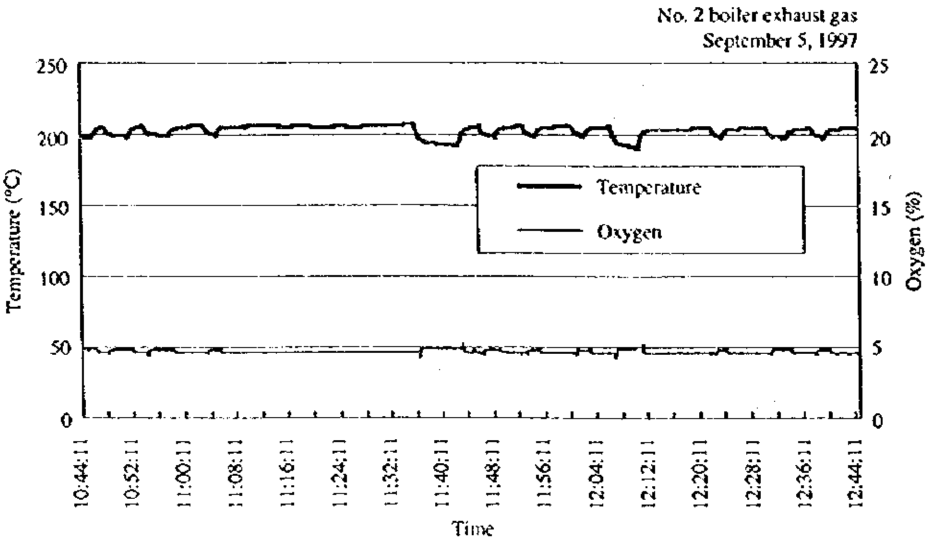
b. Utilities (heat utilization facility)

1) Measurement and analysis of components in the boiler exhaust gas

In this factory, two boilers using natural gas are installed for production processes and heating. The pressure of steam is 0.9 MPa, which is reduced at two stages. The steam at 0.7 MPa in the first stage is mainly delivered to processing of sausage etc., while the steam at 0.4 MPa in the second stage is supplied mainly for washing the live pig body, various cleanings, and space heating.

Figure 5.2.6 shows the values of oxygen content in the exhaust gas and the exhaust gas temperature measured in the flue of the No. 2 boiler that was running. According to the indication of the feedwater counter on the boiler, the amount of feedwater during measurement was 2.75 m^3/h and the load ratio to the designed capacity is approximately 70 %.

Figure 5.2.6 Measurement of Boiler (No. 2) Exhaust Gas



Oxygen content in the exhaust gas is 4.7 %, which indicates that the running status is good. However, since combustion for the boiler is controlled step by step (20 %, 50 %, 100 %), oxygen content in the exhaust gas should be checked at each step. Table 5.2.9 shows combustion calculation based on the measured value. For reference, the standard value of the air ratio is 1.3 and that of the exhaust gas temperature is 220 °C in excellent factory.

Table 5.2.9 Combustion Calculation

Preconditions	
Fuel gas	
Net heat value (kJ/kg)	26,651
Net heat value (kcal/kg)	6,365
Combustion air temperature	28
Exhaust gas temperature	203
Furnace infiltrating air ratio	0 %

Calculation Result	Theoretical Combustion	Current AR Condition
Oxygen in exhaust gas	0.0 %	4.7 %
Air ratio	1.00	1.27
Air amount (m^3/kg)	7.2	9.1
Exhaust gas amount (m^3/kg)	8.2	10.1
Exhaust gas loss rate (against fuel heat)		9.2 %

Analysis of the exhaust gas of the boiler that is being conducted for environmental control indicates that oxygen content in the exhaust gas is 5 to 6 % (at No. 1 and 2 on February 17, 1997), which means a good status.

Table 5.2.10 lists the design values for the boilers.

Table 5.2.10 Boiler Design Values

No. of units	2
Year of installation	1993
Type	Flue and smoke tube boiler VSP-4
Maker	Rucka-Slatina, BRNO C2ECHY (Poland)
Pressure and temperature	1.4 MPa, 197 °C (Saturated)
Evaporation amount	4 t/h
Fuel	Natural gas (28,800 kJ/m^3_N)
Combustion system	Gas-firing unit burner
Burner maker	Thermotechnique S.A. C. 430.2
Feedwater treatment equipment	Water is supplied after it is preheated to 100 °C Softener
Air preheater	Not available

2) Reinforcement of insulation

In this factory, the steam valves in the boiler room and production process room are not insulated. Assuming the number of installed valves based on the result of our factory survey, heat loss from these valves is calculated, the results of which are shown in Table 5.2.11.

Table 5.2.11 Calculation of Heat Radiation (Valves)

Installation Place	Environmental Temperature (°C)	Surface Temperature (°C)	Nominal Diameter (mm)	Equivalent Length (m)	Assumed No. of Units Installed	Heat Loss (kcal/h)
Boiler room						
	28	160	200	1.87	2	4,879
	28	160	150	1.78	15	26,602
	28	160	100	1.58	30	32,675
	28	160	50	1.28	20	9,341
Production shop						
	28	140	150	1.50	30	35,668
	28	140	100	1.27	50	34,823
	28	140	50	1.11	100	13,569
Total						157,556

If the steam valves are insulated, heat radiation loss can be reduced to approximately 10 %. We also found that the heat insulation portion for the hot water tank was broken at some points. Table 5.2.12 shows the result obtained by calculating heat radiation based on the surface temperature of the hot water tank.

Operation time: 4,240 h/y in 1995
Steam saving : 157,556 × 4.1868 × 0.9 × 4,240/1,000,000 = 2,517 GJ/y

Table 5.2.12 Calculation of Heat Radiation from the Hot Water Tank Surface

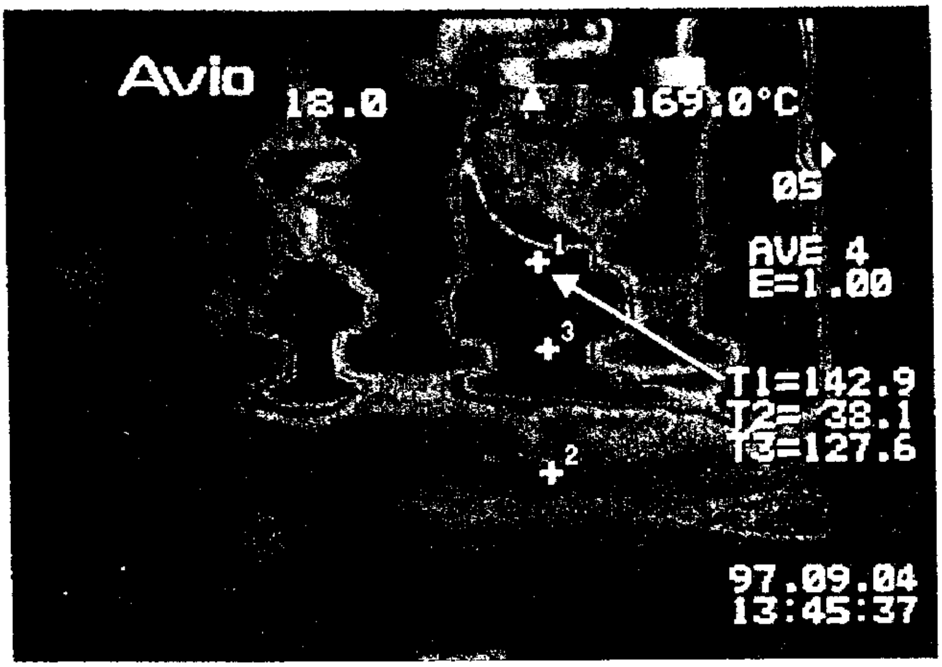
Installation Place	Environmental Temperature (°C)	Surface Temperaure (°C)	Area (assumed) (m^2)	Heat Radiation (kcal/h)
Hot water tank	28	80	20	10,294

Operation time: 4,240 h/y in 1995
Steam saving : 10,294 × 4.1868 × 0.9 × 4,240/1,000,000 = 164 GJ/y

3) Thermal image of the steam header and valves

By taking a photograph of the high-temperature portion to which heat insulation is not applied by using an infrared thermal imaging system, the high temperature at this portion can be visually represented as image colors. Figure 5.2.7 shows the image of the steam header and valves in the boiler room.

Figure 5.2.7 Infrared Thermal Image of the Steam Header



c. Utilities (electricity utilization facility)

1) Compressor for chillers

Among the compressor motors for chillers, the load for the 75 kW motor was as light as 23 kW.

Recommendable measure:
If this status is normal, change the motor capacity from 75 kW to 37 kW. Judging from the recent production status, the cooling facility seems to be slightly larger. This requires further examination of equipment capacity, etc.

Effect:
If the 75 kW motor is replaced with the 37 kW motor, power saving as the loss reduction effect will be approximately 13,200 kWh (= 1.51 kW × 8760 h), when efficiency of both motors is assumed to be 87 % and the power factor, iron loss, copper loss and its percentage, motor power factor under the current load, etc. are assumed as listed in Table 5.2.13. An annual electricity saving based on this assumption will be 13,200 kWh (= 1.51 kW × 8,760h).
Moreover, the expected effects include such as power factor improvement and making the capacity of each related equipment such as the transformer smaller.

Electricity saving: 13.2 MWh/y

Table 5.2.13 Changes in the Power Loss as a Result of Replacing the Motor

	When the motor is fully loaded					Loss under the current load (23 kW)			
	Ratings Capacity (kW)	Ratings Power Factor (%)	Loss L (kW)	Iron Loss Wi (kW)	Copper Loss Wc (kW)	Load Power Factor (%)	Copper Loss. Wc (kW)	Total Loss (kW)	Loss Difference
Current status	75	90	9.75	2.93	5.85	0.59	1.28*	4.21	
After the motor is replaced	37	85	4.81	1.44	2.89	0.80	1.26**	2.70	1.51

The iron loss and copper loss of the motor in the current status and after the motor is replaced are assumed to be 0.3 L (Wi) and 0.6 L (Wc), respectively.

* : $5.85 \times \{(23/0.59)/(75/0.9)\}^2 = 1.28$ kW

**: $2.89 \times \{(23/0.8)/(37/0.85)\}^2 = 1.26$ kW

2) Reduction of lighting electricity

Lighting in the factory is 100 to 250 Lux, which indicates a fair status.

Mercury lamps are used as outdoor lighting and electricity consumed is approximately 5 kW. These lamps were automatically turned on/off by sensors depending on brightness/darkness in the daytime and nighttime.

If these mercury lamps are replaced by high-voltage sodium lamps, energy conservation of approximately 40 % can be achieved.

A high-voltage sodium lamp is a little more expensive than a mercury lamp and its color is yellow. Therefore, after careful examination, the mercury lamps should be replaced with small-capacity sodium lamps matching the illuminance.

Electricity saving: $5 \text{ kW} \times 8{,}760 \text{ h/y} \times 0.5 \times 0.4/1{,}000 = 8.8 \text{ MWh/y}$

(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 air pollutants from this factory achieved as a result of energy conservation is compiled at each stage of energy conservation, and shown in Table 5.2.14.

Table 5.2.14 Emission Improvement by Energy Conservation Measures

Measure	Reduction [ton/year]			
	CO_2	SO_2	NO_2	Dust
Step 0				
Step 1	28	0.0	0.0.	0.0
Step 2	428	0.1	0.4	0.0
Step 3				
Step 1-3	456	0.1	0.5	0.0

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 5.2.15. Furthermore, the payback period 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 5.2.15 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	14	0.0	14	51	3.67	3.67
Step 2	178	0.2	178	455	2.55	2.55
Step 3						
Step 1-3	192	0.2	192	506	2.63	2.63

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

As evident from this Table 5.2.15, 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.

This factory has a gas-fired boiler, and thus many energy conservation items are related to the reduction of gas fuel. Gas fuels emit only a small amount of pollutants and a reduction in the pollutant emission fee in this factory is small, thus exerting only a small effect on the payback period.

b. Summary of Energy Conservation Potential

The energy conservation potential of this factory is shown in Table 5.2.16.

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 5.2.8. The relationship between energy conservation potential, the payback period, and the investment cost is shown in Figure 5.2.9.

Table 5.2.16 Summary of Energy Conservation Potential

Electricity: 0.172 PLN/kWh Natural gas: 0.514 PLN/m^3_N (28.8 GJ/m^3_N) 1 PLN = 30 yen

Item	Energy Conservation Potential							Investment	Payback period
	Fuel			Electricity			Total		
	GJ/y	10^3 PLN/y	%	MWh/y	10^3 PLN/y	%	10^3 PLN/y	10^3 PLN	year
Step 1									
1. Providing a curtain at entrance and exit	505	9	1.0	27	5	1.0	14	51	3.8
Subtotal	505	9	1.0	27	5	1.0	14	51	3.8
Step 2									
2. Improving the condensate recovery rate in the heating process	5,008	89	10.0				89	206	2.3
3. Insulating the steam valves	2,517	45	5				45	120	2.7
4. Insulating the hot water tank	164	3	0.3				3	0	0.0
5. Introducing the fresh-air				215	37	8.1	37	103	2.8
6. Changing compressors for cooling and chilling				13	2	0.5	2	11	4.9
7. Lighting: Changing to sodium lamps				9	2	0.3	2	15	9.7
Subtotal	7,689	137	15.4	237	41	8.9	178	455	2.6
Total	8,194	146	16.4	264	45	10.0	192	506	2.6

As of 1996: Fuel consumption: 50,083 GJ/y
Electricity consumption: 2,650 MWh/y (27,178 GJ/y)
Total: 77,261 GJ/y

Figure 5.2.8 KOSCIAN MEAT Energy Conservation Potential

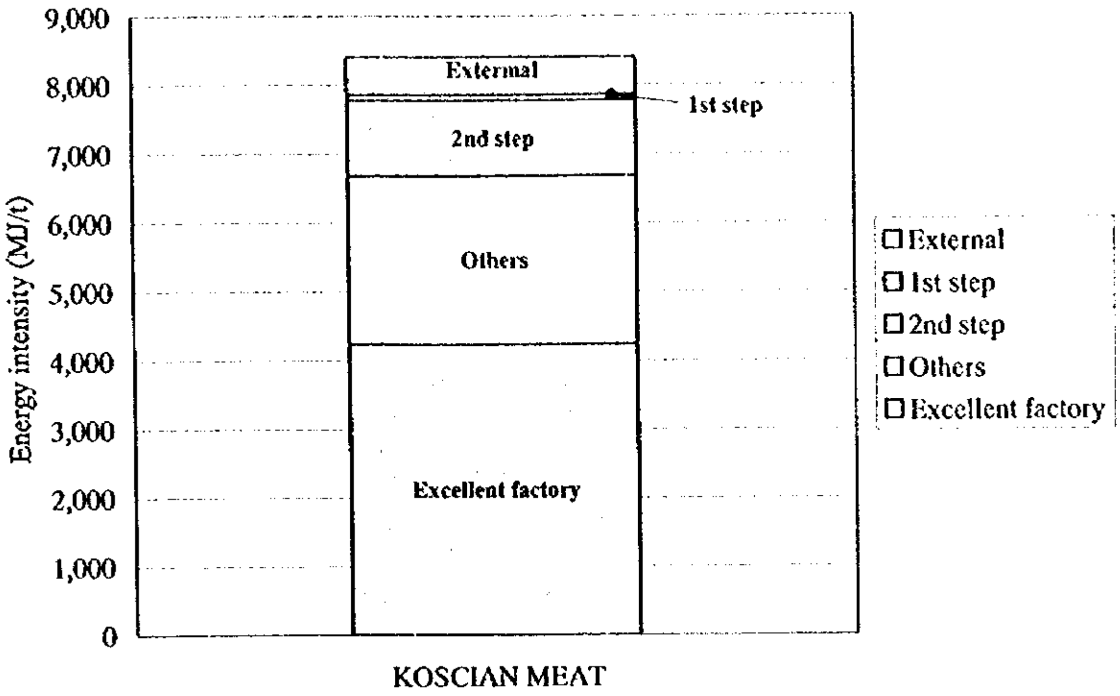
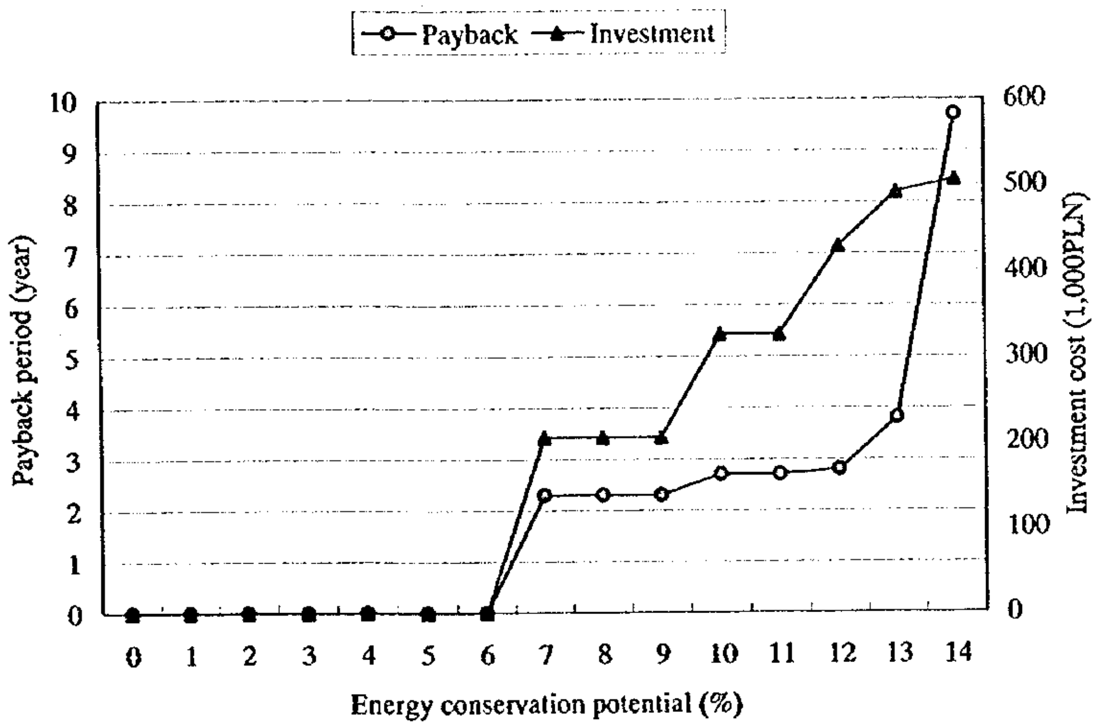


Figure 5.2.9 KOSCIAN MEAT Energy Conservation potential



5.3 Results of the Study at the Lubmeat Plant

(1) Study poriod: September 17, 18 and 19, 1997

(2) Members of the study team

a. JICA Team

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

b. Local consultants

Research Center of Warsaw University of Technology
Mr. Maciey Chorzelski: Heat management
Mr. Wrobel Waldemar: Electricity management

(3) Interviewees

Mr. Andrzej Latkowski	:	Chairman
Mr. Andrzej Szymczak	:	President, Technical and Transportation Director
Mr. Jeug Poniewozik	:	Vice President
Mr. Aleksander Wojtowicz	:	Manager of Energy Department, Leader of Cooling Section
Mr. Henryk Dyrka	:	Electrical Section
Mr. Andrzej Jedlewski	:	Main Technical Specialist

5.3.1 Profile of the Plant

(1) Plant name: Zaklady Miesne <Lubmeat> Lublinie

(2) Plant address: 20-207 Lublin ul, Turystyczna 9, Poland

(3) No. of employees: 630

(4) Major products: Meat, ham & sausages and canned products

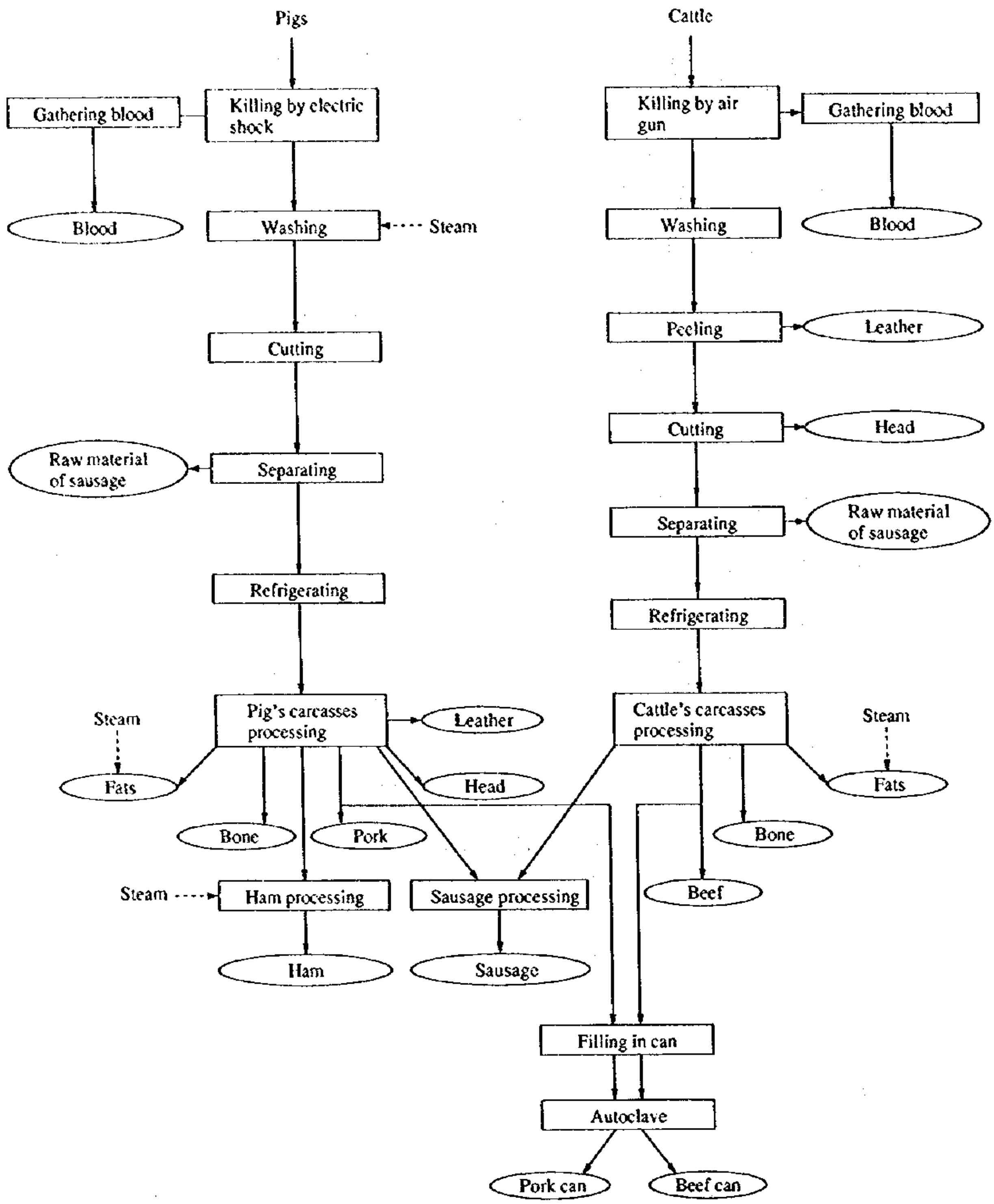
(5) Production capacity

(6) Overview of the process

Pigs (80 %) and cattle (20 %) are killed, and their blood is removed. Then the bodies are washed with hot water and are divided into two segments; thereafter, they are put in the chilled room for processing of ham/sausage.

Separately, products are shipped as carcasses. Meat cans are produced through retort sterilization. Figure 5.3.1 shows the process flow. Steam is supplied from the boiler of a contracted company.

Figure 5.3.1 Process Flow



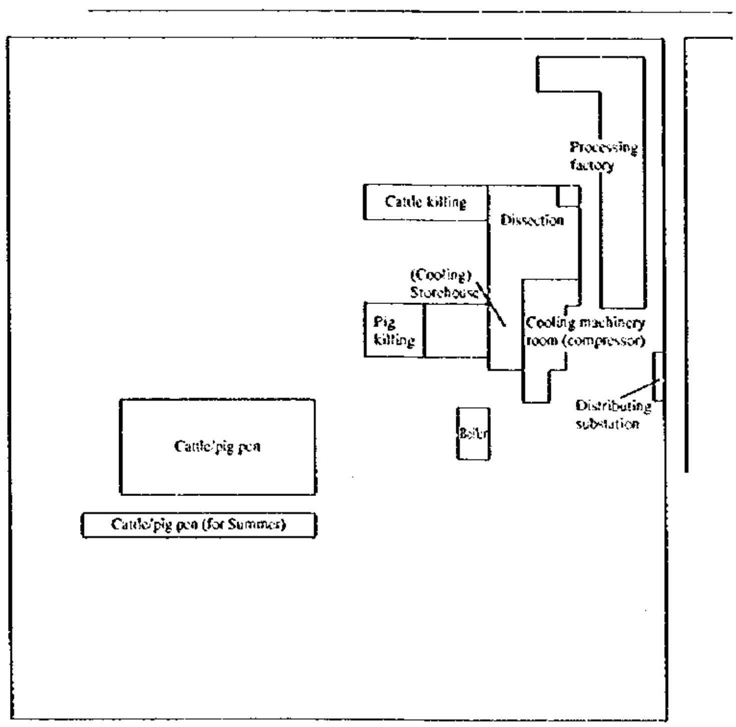
(7) Profile of this plant

This plant was founded as a state-run plant. In the site area of 10.5 ha, the plant has operated the enterprises such as pig/cattle butchery, meat processing, steam supply, etc. Since the market in Russia had abruptly reduced, this factory became a company in need of reorganization and has been challenging rationalization since three years ago. The steam supply business was separated as another company and the 4-ha land and facilities as well as steam piping for the boiler were sold. The number of employees in the headquarters was reduced from 1,600 to 542.

Since two years ago, this plant has been invested from the National Investment Fund while the revolving fund has increased. Although beef production has been reduced by 70 % and pork by 60 % compared with the peak time, this company occupies the middle-level position in this industry because of the high quality level of the products. The company is challenging market recovery.

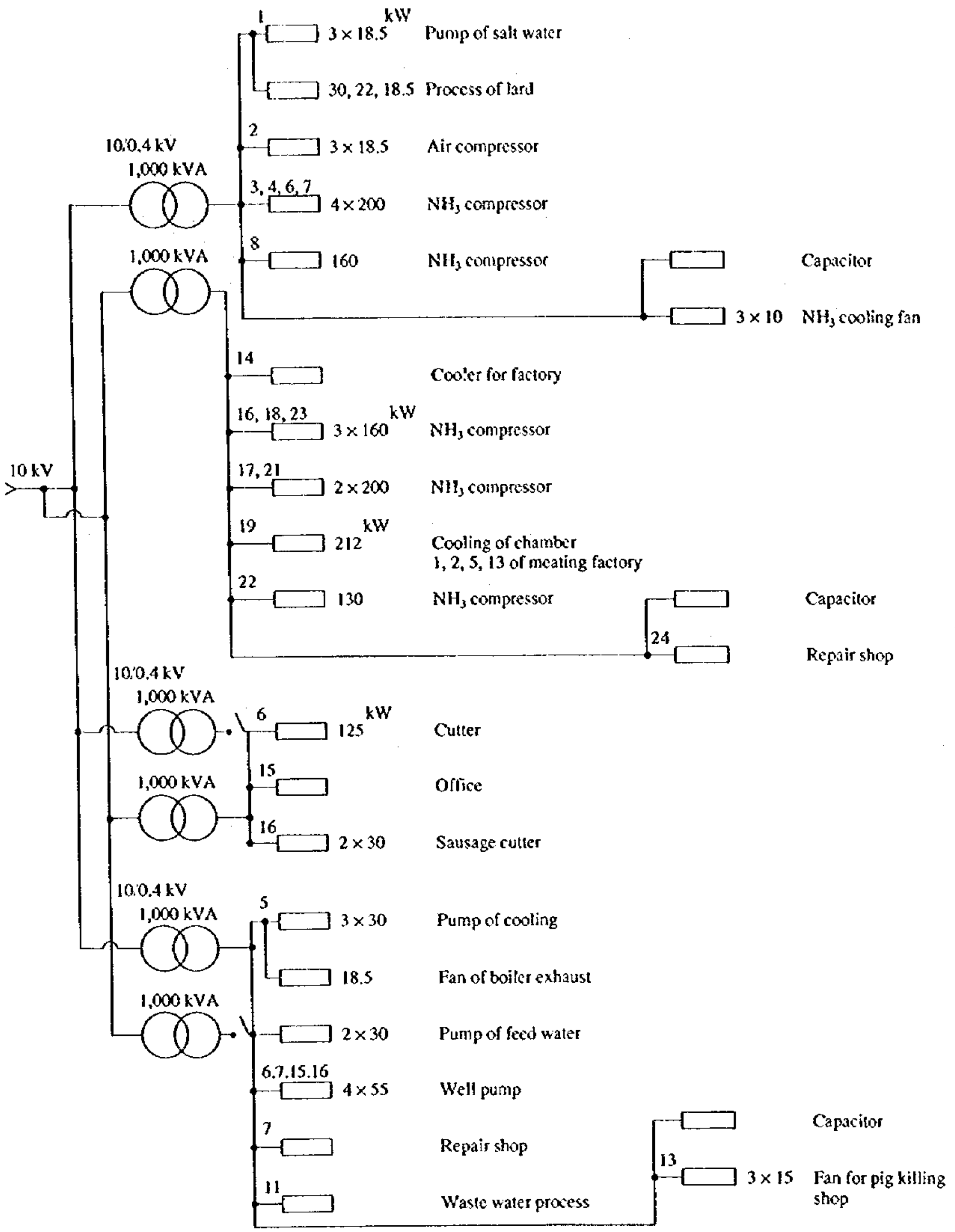
(8) Plant layout

Figure 5.3.2 Plant Layout



(9) One line diagram

Figure 5.3.3 One Line Diagram



(10) Outline of major equipment

Table 5.3.1 Major Equipment

Factory	Number	Specification
Pig washing bath	1	Shower 30 °C, Bath 65 -- 68 °C 4 min
Beef wahing	1	Shower 30 °C
Treatment machine	1	122.5 t/d
Meat slicer	2	33 kg/min 2,000 kg/h
Neoder	2	200 kg
Canning sterilizer	4	0.63 t/patch 2 h 121 °C 7 times/d
Chopper	9	30 kW + 20 kW × 8
Cutter	3	120 kW, 50kW, 30 kW
Chiller	11	200 kW × 6, 160 kW × 4, 130 kW NH_3 type
Pump	19	50 kW × 3, 30 kW × 10, 22 kW × 3, 18 kW × 3
Fan	7	20 kW × 7
Separator	3	30 kW, 25 kW × 2

(11) Energy price and heat value

Table 5.3.2 Energy Price and Heat Value

	Energy price	Heat value
Electricity	0.165 PLN/kWh	10.258 GJ/MWh
Steam	0.068 PLN/kg	2.75 GJ/t (0.55 MPa, 155 °C)
Coal	0.135 PLN/kg	

5.3.2 Energy Consumption Status

(1) Trend of production

Table 5.3.3 Trend of Produciton

(t/y)

Year	1992	1993	1994	1995	1996
Production	14,971	13,646	11,433	8,164	7,096

(2) Trend of energy consumption

Table 5.3.4 Trend of Energy Consumption

	Unit	1992	1993	1994	1995	1996
Steam	t	77,000	61,264	27,000	24,000	20,389
Electricity	MWh	6,747	5,992	4,588	4,978	4,481

Table 5.3.5 shows monthly energy consumption for 1996 and 1997.

Table 5.3.5 Monthly Energy Consumption

(1996 – 1997)

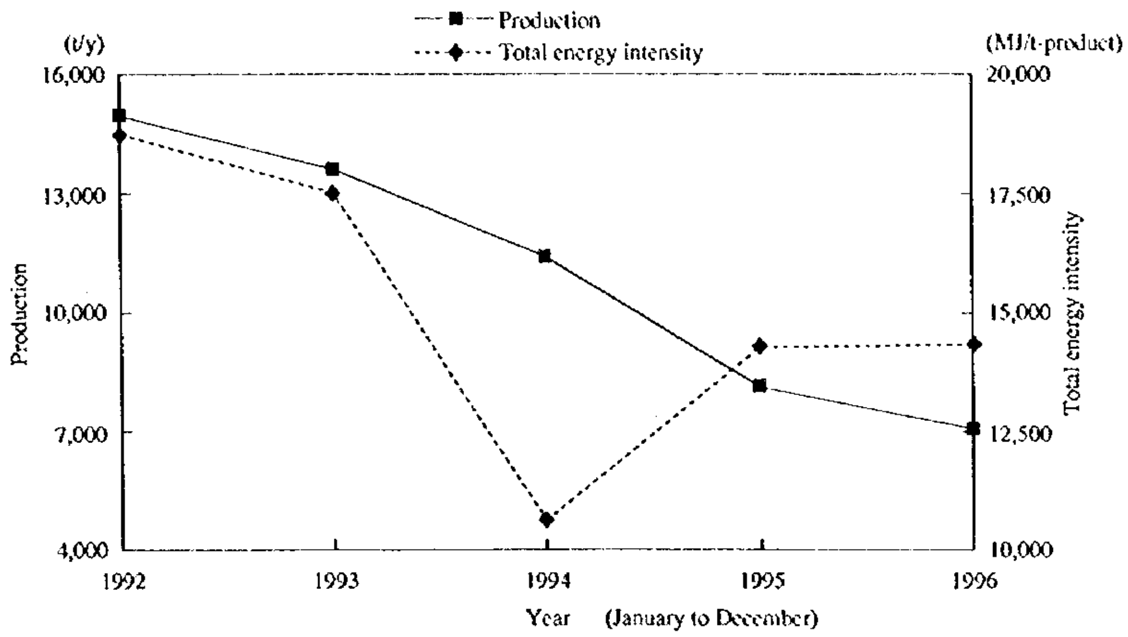
Energy		1996							1997							
	Total	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.
Steam (t)	22,936	1,351	1,580	1,390	1,490	1,760	1,690	1,892	1,970	1,420	1,902	1,103	1,426	1,336	1,404	1,222
Electricity (MWh)	5,867	393	403	399	350	387	368	370	361	311	361	390	433	427	462	452

(3) Trend of energy consumption and intensity

Table 5.3.6 Trend of Energy Intensity

	Unit	1992	1993	1994	1995	1996
Consumption						
Steam	GJ	211,750	168,476	74,250	66,000	56,070
Electricity	GJ	69,197	70,969	47,055	51,054	45,957
Intensity						
Steam	MJ/t-product	14,144	12,346	6,494	8,084	7,902
Electricity	MJ/t-product	4,622	5,201	4,116	6,254	6,477
Total	MJ/t-prpduct	18,766	17,547	10,610	14,338	14,379

Figure 5.3.4 Trend of Production and Total Energy Intensity



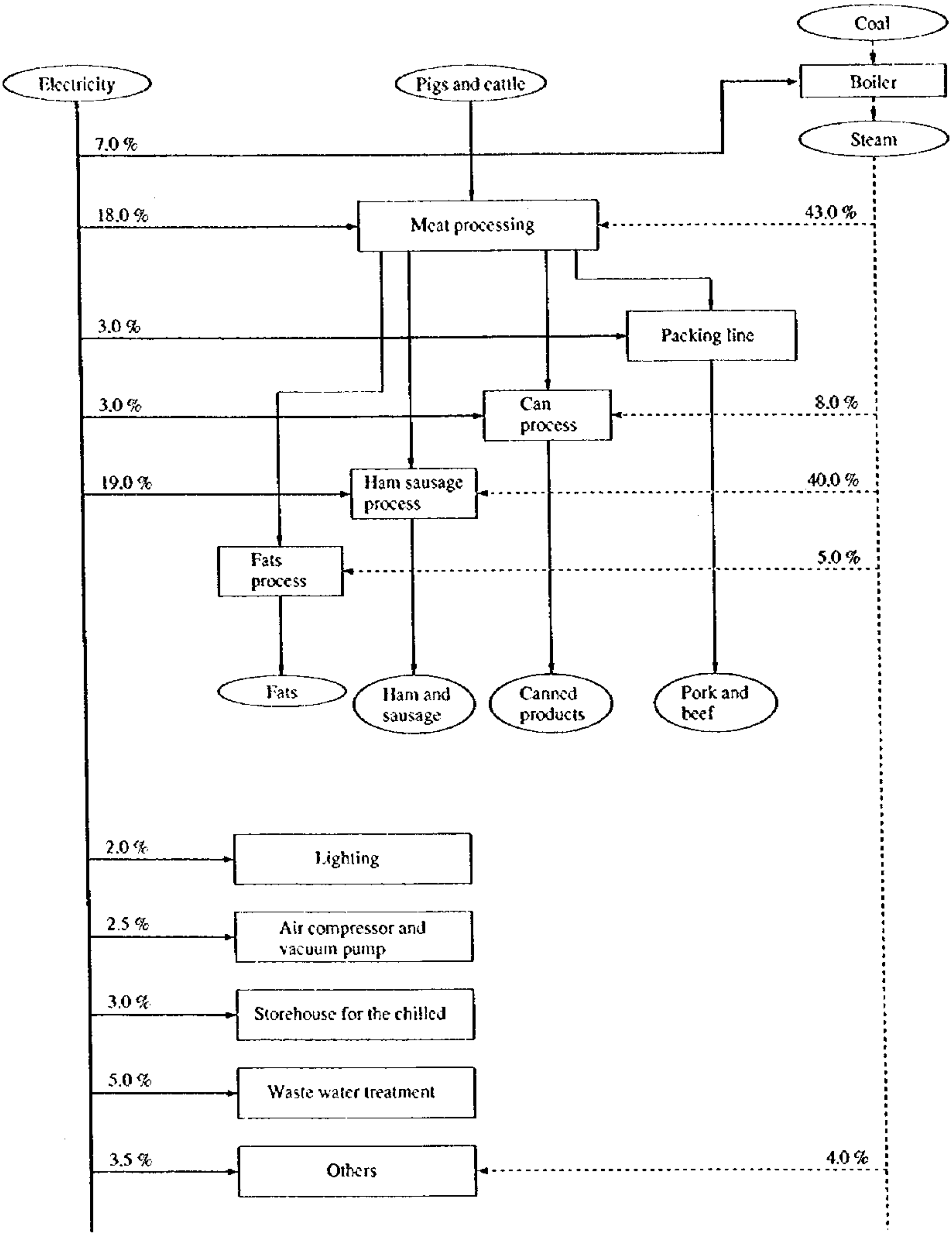
The production amount shows a tendency to deline, while the total energy intensity is at a high level. It should be noted that as shown in Table 5.3.6, the intensity is increasing compared with that in 1994 although unevenness is recognized since 1992.

(4) Energy cost ratio to production cost

Steam	: 3.9 %
Electricity	: 2.0 %
Total	: 5.9 %

(5) Energy flow

Figure 5.3.5 Energy Flow



5.3.3 Energy Management Status

(1) Setting the energy conservation target

a. Setting the target value

No explicit target value is set. The policy of promoting the short- and medium-term activities is not satisfactory.

b. Problems in promotion of energy conservation

While the technical level is fairly high, the energy conservation technology is insufficient due to limited information and development sources limited in West Europe. There are many problems such as shortage of measuring equipment.

(2) Systematic activities

a. Installing a dedicated section for energy conservation

The dedicated members are available in the rationalizing and restructuring organization but allocation of technical staff is not satisfactory.

b. Installing an energy conservation committee

No energy conservation committee is provided.

c. Management stance toward energy conservation

This factory is in the course of restructuring and the management is highly concerned about energy conservation. Purchasing steam from a coal boiler is monthly contracted, and also the effort for management enhancement is being made, which alone are not enough. It is necessary to further promote energy conservation for production processes including air conditioning. The present chairman took his post three years ago. He, who is positively engaged in restructuring, agrees with setting up the target for 50 % energy conservation. Therefore, his efforts are expected. They make efforts toward the recovery of the market and rationalization; however there is still a plenty of room for improvement as well as many issues to be resolved.

(3) Data-based management

a. Grasping the energy used

Energy used by the entire factory has been recorded well.

b. Grasping the energy used by major facility

Engineers understand the time-based measurement results by process and also have a good grasp of the factory energy balance for such as sausage, lard oil, etc. and the equipment specifications and capacity.

c. Grasping the energy intensity for major products

Data about the energy used by product has not been recorded on a regular basis, but calculation based on the energy consumption among the data mentioned in the item b. above is made available. No organized data on the energy intensity used for monthly management is available.

d. Installation of measuring equipment

Electricity in the main line can be roughly known for each system in the electricity room. Since no flow meter is provided in the steam line, presumption based on the equipment specifications is only possible. The flow meter of steam should be installed in the future.

e. Production management and cost management

Under the present circumstances where carcasses are brought from other companies and sales promotion of dressed meat is in progress, the produced/sold volume can be easily grasped, and thus further efforts in cost management are required. Presently, top priority is put on personnel reduction. The dedicated staff are available.

(4) Training of employees

Training on energy conservation is not proceeded in an organized way.

(5) Plant engineering

Presently, the facility capability is too large and the operation time per day is very short.

It is praiseworthy that food sanitation management is implemented preferentially. Maintenance does not seem to be positively performed from the viewpoint of energy conservation. The production schedule and daily management should be enhanced to make effective use of equipment. Currently concentrated production has not been achieved yet.

5.3.4 Problems and Measures related Energy Use

(1) Comparison of the energy intensity with the excellent factory

Table 5.3.7 shows the result of comparing the energy intensity of Lubmeat with that of the excellent factory. As shown in Table 5.3.8, the energy intensity of the excellent factory was calculated based on the data for each of the separate butchery and carcass factory and ham & sausage factory.

Table 5.3.7 Comparison of Energy Intensity

	Unit	Lubmeat	Excellent Factory	Difference
Production amount	t	7,096	24,353	Δ17,257
Electricity	MJ/t	6,477	3,352	3,125
Steam	MJ/t	7,902	2,543	5,359
Total energy		14,379	5,895	8,484

Table 5.3.8 Data of Excellent Factory

	Production	Energy intensity		Energy intensity [Integrated meat factory (Ham & sausage rate: 60 %)]	
		Fuel	Electricity	Fuel	Electricity
Butchery and carcass factory	24,353 t/y	844 MJ/t-product	2,272 MJ/t-product	844 MJ/t-product	2,272 MJ/t-product
Ham & sausage factory					
1) Raw meat storage	14,400 t/y		1,200 MJ/t-ham		0 MJ/t-product
2) Processing		2,832 MJ/t-ham	1,800 MJ/t-ham	1,699 MJ/t-product	1,080 MJ/t-product
Total	–	–	–	2,543 MJ/t-product	3,352 MJ/t-product

(2) Estimating of the energy conservation potential

(2)-1 Difference due to external factors

Both Lubmeat and excellent factory perform operations from butchery to carcass production. Therefore, there is no intensity difference due to the material/product difference. Lubmeat is located in a vast site, with steam supplied from the place far apart, and additionally in a cold region compared with the excellent factory. The heat radiation loss in Lubmeat is lager than that in the excellent factory. Assuming that amount of energy required for heating is 30 %, of which 10 % is estimated to come from radiation heat loss due to the temperature difference, with data in 1996 as an example, the corrected fuel intensity will be 7,902 × 0.9 = 7,112 MG/t. This is 8 times that of the Excellent factory, and significantly high. The difference in the energy intensity due to the above-mentioned external factors is as follows:
Difference in energy intensity due to external factors: 7,902 × 0.1 = 790 MJ/t

(2)-2 Difference due to technical factors

Energy conservation potential is divided into the following three steps to sort out the potential.

Step 1: Enhancing the management
Step 2: Improving the equipment
Step 3: Improving the processes

a. Process

1) Ham/sausage heating process

The filled ham, sausage,etc. are fed to the heating process. Ham and sausage filled in the well-permeable casing (e.g. natural gut, cellophane, etc.) are smoked and then boiled. Ham and sausage filled in the air-tight casing are fed to the boiling process to be boiled. The heating time is set so that heating will be performed at 70 to 80 °C and the center part will be heated to 63 °C for at least 30 minutes.

Most smoke generators have been automated in the excellent factory but care must be taken to flavor. However, smoking is performed for 1/5 of the traditional smoking time. The condensate is recovered from steam heating in addition to reduction of the smoking time, thus contributing significantly to energy conservation.

Lubmeat recovers the condensate but the condensate recovery line is long and moreover is not insulated; hence the recovery effect is estimated to be extremely low. As shown in Figure 5.3.5, the ham and sausage process uses 40 % of entire steam.

The energy conservation effect can be expected if the smoking time is reduced in the similar way as employed in the excellent factory. At the same time, improvement of the condensate recovery effect should be discussed. Implementation of this improvement will allow a 10 % or more steam saving.

Thus, at least the following reduction in steam intensity can be expected:

7,902 MJ/t × 10 % = 790 MJ/t-product (5,606 GJ/y)

2) Fresh-air intake

At Lubmeat, the separating operation is performed in the low-temperature room using the chiller in summer. Electricity consumption in winter is larger throughout the year, while electricity consumed by the chiller in summer is large as well.

The excellent factory, in some cases, sterilizes and filters fresh-air in winter and takes it into the workshop for air conditioning of the chilled room (4 °C) and reserved room (10 °C) to reduce the electricity load for the chiller.

Since the dust content in fresh-air is difficult to grasp quantitatively when this method is adopted, it is necessary to enhance the filter's dust collecting efficiency for a while.

If 1/2 of 3 % electricity (Figure 5.3.5) consumed by the chilled storehouse is saved by using the fresh-air intake system, the electricity saving will be as follows:

$6,477 \times 0.03 \times 0.5 = 97$ MJ/t-product (67 MWh/y)

3) Installation of a curtain at the exit/entrance

For the room temperature in the meat plant, the butchery yard should be at 15 °C, the chilled room at 4 °C, and the processing room at 10 °C. In the lard factory, where a double cooker is used, air conditioning should be controlled by installing a curtain at the entrance/exit. If fresh-air is at a high temperature in summer, a curtain should be provided at the entrance/exit to prevent entry of fresh-air.

If the curtain is provided in this plant, the energy intensity is expected to be improved by approximately 2 %, i.e., 1 % for steam and 1 % for electricity.

Improvement in the steam intensity : $7,902 \times 0.01 = 79$ MJ/t-product (561 GJ/y)

Improvement in the electricity intensity: $6,477 \times 0.01 = 65$ MJ/t-product (45 MWh/y)

4) Yield improvement

Table 5.3.9 shows the breakdown of the production and sale amount for the processing yard in 1994 and 1996, which were obtained during our factory survey.

Table 5.3.9 Breakdown of Production and Sales Amount

	1996			1994		
Dissected weight of pig	3,817,100 kg		78.5 %	4,029,700 kg		79.8 %
Dissected weight of cattle	1,042,600		21.5 %	1,019,500		20.2 %
Sales amount (for the processing yard)						
Can	208,400 kg	3,673,600		288,000 kg	3,523,000	
Sausage	2,824,000			2,690,000		
Paste	534,900			482,000		
Retort-processed sausage	106,300			63,000		
Fats	418,000			580,000		
Fats for industrial use	15,200			43,000		
Pet food (for dogs)	34,300			40,800		
Chopped meat	49,100			26,400		
Powder feed	76,100			33,000		
Liquid feed	361,400			429,000		
Total sales amount (for processing yard)	4,690,700			4,675,200		
Total pig/cattle dissected weight	4,859,700			5,049,200		
Yield	96.52 %			92.59 %		
Total production and sales by the company	7,096 t			11,433 t		
(Total carcass)	(2,405 t)			(6,758 t)		

The amount processed in its own factory is small and a yield of 96.52 % is less satisfactory. The reason why the sales amount is on the increase is that warm pig/cattle carcass (actually refrigerated one) is received from other company and shipped. Actually, there may be considerably serious problems in terms of energy conservation. If the yield of 98.5 % is aimed at, 2 % energy conservation can be expected.

Improvement in the electricity intensity: $6{,}477 \times 0.02 = 130$ MJ/t (90 MWh/y)

Improvement in the steam intensity : $7{,}902 \times 0.02 = 158$ MJ/t (1,121 GJ/y)

The amount produced and processed in the factory in August, 1997 is shown below. Cattle are getting increasingly difficult to procure.

Pig line	485.2 t	84.1 %
Cattle line	91.6 t	15.9 %
Total	576.8 t	100 %

Sausage should preferably be composed of 70 % pork and 30 % beef. Since the rate of beef produced and processed in the factory has reduced, quality control should be adequately performed so that flavor should be maintained. In the future, production of ham mainly consisting of pork will increase but this factory must carry on a keen competition in quality and prices in the ham market. For cost reduction, energy conservation will be an essential issue.

5) Others

In the factory, the following are under discussion:

① Installation of heat exchangers (for space heating by heat recovery)
② Recycling the cooling water for the powder feed production line and lard production line
③ Heat recovery in the canning/sterilizing process
④ Installation of an watt-hour meter at the electricity distributing station
⑤ Changing the cooling system from manual control to semi-automatic control
⑥ Reduction of the site area and selling the unnecessary land

For ③ heat recovery in canning/sterilizing process, the retort cooker is not insulated, resulting in extremely large heat radiation loss. Considering cooling water is discarded, there is still some allowance for heat recovery and thus the destination for using recovered heat should be examined. Similarly both ① and ② should be considered in terms of heat recovery and its utilization.

In the heating process for cans, 8 % of the entire steam is used and 20 % is used for heating the water.

If a half of water heating steam can be reduced by implementing ①, ②, and ③, the steam intensity saving effect will be as shown below.

In the present situation where the amount of cans produced is very small, investment for improvement should be examined according to the production plan.

$$7{,}902\ \text{MJ/t} \times 0.30 \times 0.5 = 1{,}185\ \text{MJ/t-product}\ (8{,}409\ \text{GJ/y})$$

b. Utilities (heat utilization facility)

1) Measurement and analysis of exhaust gas from the boiler

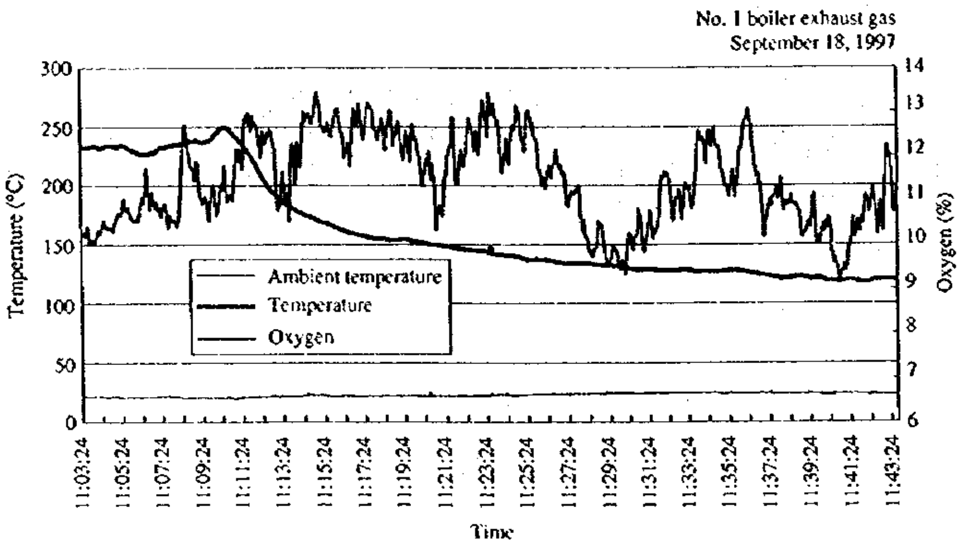
This plant has 3 coal-fired boilers running. The plant had purchased the steam from the adjacent Daewoo heat supply station till March 1997; from April in the same year onward, however, the coal-fired boilers, which have been available for a long time but not in use, have been operated to generate steam for use.

Table 5.3.10 shows the result of measuring the oxygen content in the exhaust gas from 3 boilers.

Table 5.3.10 Boiler Exhaust Gas Measurement Results

		No. 1 Boiler	No. 2 Boiler	No. 3 Boiler
Oxygen	Average	11.4 %	14.4 %	15.7 %
	Maximum	13.4 %	16.8 %	16.1 %
	Minimum	9.1 %	10.7 %	15.3 %
Period	From	11:03:24	12:52:38	12:31:24
	To	11:43:42	13:49:28	12:48:36

Figure 5.3.6 Measurement of Boiler Exhaust Gas



For No. 1 boiler, the air ratio was calculated from the measured oxygen content in the exhaust gas. Furthermore, on the assumption that the exhaust gas temperature remains unchanged, the effect of fuel saving after improving the air ratio was obtained. The results are shown in Table 5.3.11, where the minimum exhaust gas oxygen content among those for 3 boilers was used as the feasible value for improving the air ratio. For the exhaust gas temperature, the mean value for the first 7 minutes of the above-mentioned measurement time was used as a typical value. Table 5.3.12 summarizes the results of boilers.

Table 5.3.11 Boiler Combustion Calculation (No. 1 Boiler)

Preconditions

Coal	
Net heat value (kJ/kg)	22,396
Net heat value (kcal/kg)	5,350
Ash content	17.00 %
Water content	6.00 %
Combustion air temperature	22.6
Exhaust gas temperature	235
Exhaust air temperature after air preheater	235

Note: Measurement was conducted at the flue in front of the smoke stack.

Calculation Result

	Theoretical Combustion	Current AR Condition	After AR Improvement
Exhaust gas oxygen	0.0 %	11.4 %	9.1 %
Air ratio	1.00	2.16	1.75
Air flow rate (m^3/kg)	6.4	13.8	11.2
Exhaust gas volume (m^3/kg)	6.7	14.2	11.5
Exhaust gas heat loss rate (to combustion heat)		18.7 %	15.4 %
Fuel reduction rate			3.9 %

Note: The oxygen content after air ratio improvement indicates the minimum of the measured O_2 values.

Table 5.3.12 Fuel Reduction Effect of Air Ratio Adjustment

	No. 1	No. 2	No. 3
Oxygen, actual	11.4 %	14.4 %	15.7 %
Air ratio	2.16	3.13	3.89
Exhaust gas temperature	235	235	235
Exhaust gas heat loss	18.7 %	26.5 %	32.6 %
Oxygen, adjusted	9.1 %	9.1 %	9.1 %
Fuel saving	3.9 %	13.1 %	20.3 %

Table 5.3.13 shows the fuel components used for these combustion calculation.

Table 5.3.13 Fuel Coal Composition

C	H	O	N	S	Water Content	Coal Ash Content	Heat Value (kcal)	Heat Value (kJ)
81.5 %	4.9 %	11.4 %	1.3 %	1.1 %	6.0 %	17.0 %	5,350	22,396

Table 5.3.14 lists the boiler specifications. For the boiler equipment, each measuring instrument for boiler feedwater volume, steam delivery volume and circulating water flowrate is provided on the monitoring panel, but these meters are not operating.

As shown in Table 5.3.12, the heat loss through the boiler exhaust gas is 19 to 33 %, from which the boiler thermal efficiency is estimated to be approximately 60 to 75 %. Replacing this boiler with an upgraded gas-firing packages type will presumably lead to a 90 % boiler thermal efficiency.

Average fuel saving ratio for 3 boilers: (3.9 + 13.1 + 20.3)/3 = 12.4 %
Improvement of fuel intensity: 7,096 × 0.124 = 880 MJ/t (6,244 GJ/y)

Table 5.3.14 Boiler Equipment

Item	Design Value	Remarks
No. of units installed	3	Same type
Year of installation and operation	1957/1961	
Manufacturer	Rafako	Raciborz, Poland
Type	Forced circulating type water tube boiler	
Model	PLM 2.5	
Evaporation	4 t/h	
Pressure and temperature	1.0 MPa (maximum)	0.7 MPa (working maximum)
Fuel	Hard coal, 22,400 kJ (net/kg)	
Firing system	2-stokers/furnace	
Heating area	206 m^2	
FDF	2 × 2.2 kW	
IDF	1 × 20 kW	
Feed pump	Motor-driven: 2 units	
	Steam-driven: 1 unit	
Circulating water pump	Motor driven	

2) Reinforcement of heat insulation

In this plant, some high-temperature portions of steam valves, etc. are provided with no heat insulation. The calculation of heat loss from the number of non-insulated valves assumed based on the result of our factory survey is as shown in Table 5.3.15. From this table, it is found that heat value equivalent to approximately 0.4 t of steam is lost. Providing these valves with only a simple type heat insulation can reduce the heat loss by 1/10. Additionally, for an example of heat radiation from the plane surface, Table 5.3.15 shows the heat radiation amount from the end plate of the deaerator for the boiler.

Operation time: 2,120 h/y in 1995
Steam saving : 1,085,198 × 0.9 × 2,120/1,000,000 = 2,071 GJ/y

Table 5.3.15 Heat Loss from Non-insulated Valves

Nominal Diameter (mm)	Equivalent Length (m)	No. of Units Installed (Units)	Heat loss (kcal/m/h)	Heat Loss (kcal/h)	Heat Loss (kJ/h)	Equivalant Steam (kg/h)
25	1.22	200	195	47,493	198,846	79
50	1.11	150	346	57,668	241,444	96
100	1.27	100	654	83,103	347,934	139
150	1.5	50	946	70,931	296,974	118
Total				259,195	1,085,198	432
Example of heat loss from the plane surface	Deaerator end plate (m²)		(kcal/m²)			
	1.77		847	1,497	6,268	2

Preconditions for calculation: Room temperature: 20 °C,
Valve surface temperature: 150 °C,
Plane surface temperature: 100 °C,
Steam heat value: 600 kcal/kg = 2,512 kJ/kg

3) Measurement and analysis of cooling tower water temperature

In the chilling cycle, the ammonia with the pressure increased by the compressor exchanges heat with the cooling water through the radiator. This cooling water releases the heat into the atmosphere to lower the temperature at the cooling tower installed at the outside, thus to be recycled for re-use. A lower cooling water temperature can reduce the volume of recirculating water, thus allowing the pump motor power to be reduced.

This plant employs a direct-contact type forced ventilating cooling tower. Table 5.3.16 shows the result of measuring the temperature of each part of the cooling system.

Table 5.3.16 Temperature of Cooling Water Tower

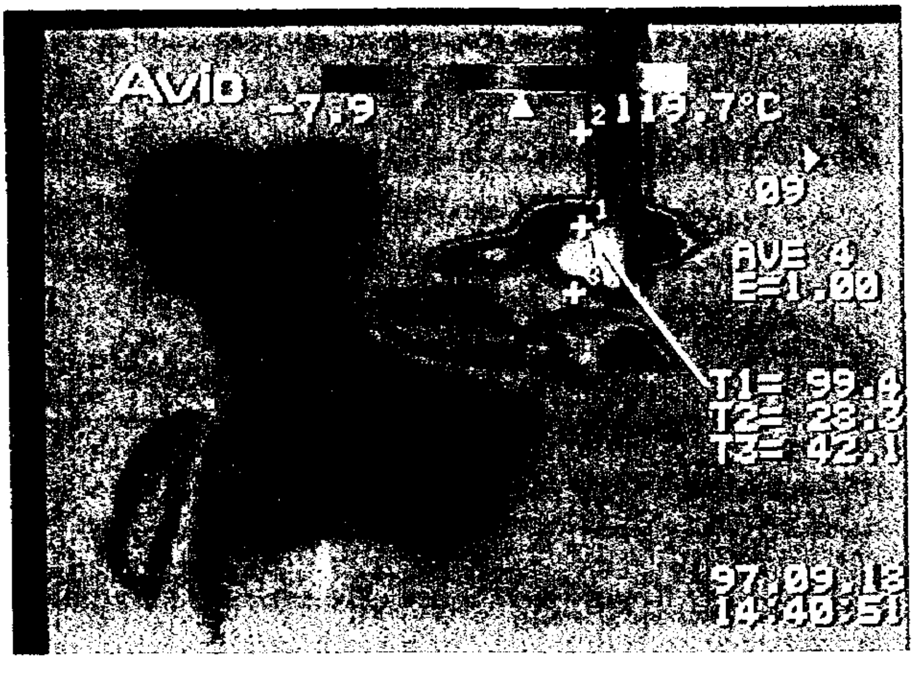
Item	Temperature	Remarks
Return water temperature	22.9	Return water tube surface temperature
Tower bottom water temperature	20.2	Filling layer bottom water temperature
Outer air temperature (Dry bulb temperature)	19.3	Ambient atmosphere
Atmospheric humidity	60 % – 80 %	Estimated value (occasionally with light rain)
Wet bulb temperature equivalent to atmosperic humidity	15 – 17 °C	

For a direct contact type cooling tower, ideally the cooling water (lower than the outer air dry bulb temperature) should be cooled to the outer air wet bulb temperature, but actually the cooling water temeperature is slightly higher than the wet bulb temperature. However the measurement result shows that the water temperature after cooling is higher than the outer air dry bulb temperature, which is presumably due to some possible deviation in the water spraying in the inside of the cooling tower. This needs to be further studied.

4) Monitoring by means of an infrared thermal imaging system

The use of an infrared thermal imaging system allows the temperature distribution of equipment to be recorded as an image; thus, heat insulation status can be visually checked. Figure 5.3.7 shows an example of thermal image of a heat exchanger for produciton of cooling water. This exchanger uses low-temperature ammonia as a cooling medium to produce cooling water. There is a frost found on the cooling water entry/exit tube which is not provided with cold insulation work. The temperature of the heat exchanger body, which is provided with cold insulation, is nearly equal to that of the outer air.

Figure 5.3.7 Thermal Image of Cooling Water Heat Exchanger (Cooling Water Producing System)



c. Utilities (electricity utilization facility)

1) Peak electricity demand suppression and electricity saving for the power distribution equipment

Four power transformers (1,000 kVA) are running. As a result of measuring the demand continuously for 30 minutes, it was found that the maximum electricity was 1,030 kW and electricity in midnight was 400 kW as shown in Figure 5.3.8. Therefore, the load is not more than approximately 30 % of the facility capacity. However, peak electricity occurred for about three hours from 6:25 and for about two hours from 10:30, during which 2,100 kW (maximum) was recorded.

If the current operation status continues, the following actions will need to be taken:

Recommendable measures:

① The low-voltage side of each substation should be connected by using inexpensive overhead cables and a transformer should be shut down.

② The cause of peak electricity between 6:00 to 9:00 in the morning and between 11:00 -- 12:00 in the daytime should be considered and discussed and the operation mode reducing electricity should be studied and implemented. (Example: Shifting the starting time)

③ In the company-wide level, the plan for reduction of electricity for cooling used throughout a day should be discussed.

Effects:
The time in which electricity used is 25 % or less of the transformer capacity is about 16 hours a day.
Although the transformers in use can be reduced to a half (2 transformers) for this time zone, one transformer needs to be removed for the operation.
The total load is assumed to be approximately 1,000 kW (12 hours in which the load is 800 kW or less), cosϕ 85 %, and losses of the 1,000 kVA transformer 2.05 kW (iron loss: Wi) and 11.33 kW (copper loss: Wc).
Power losses before and after shutdown of a transformer are shown in Table 5.3.17. The electricity saving effect is approximately 1.00 kW and annual saving is approximately 8.8 MWh.

Electricity saving: 8.8 MWh/y

Table 5.3.17 Transformer Capacity Reduction and Loss Changes

	Transformer capacity (kVA)	Iron loss W_i (kW)	Copper loss W_c (kW)	Total loss (kW)	Power saving (kW)
Current status	4 × 1,000	4 × 2.05	3.18*	11.38	
After improvement	3 × 1,000	3 × 2.05	4.23	10.38	1.00

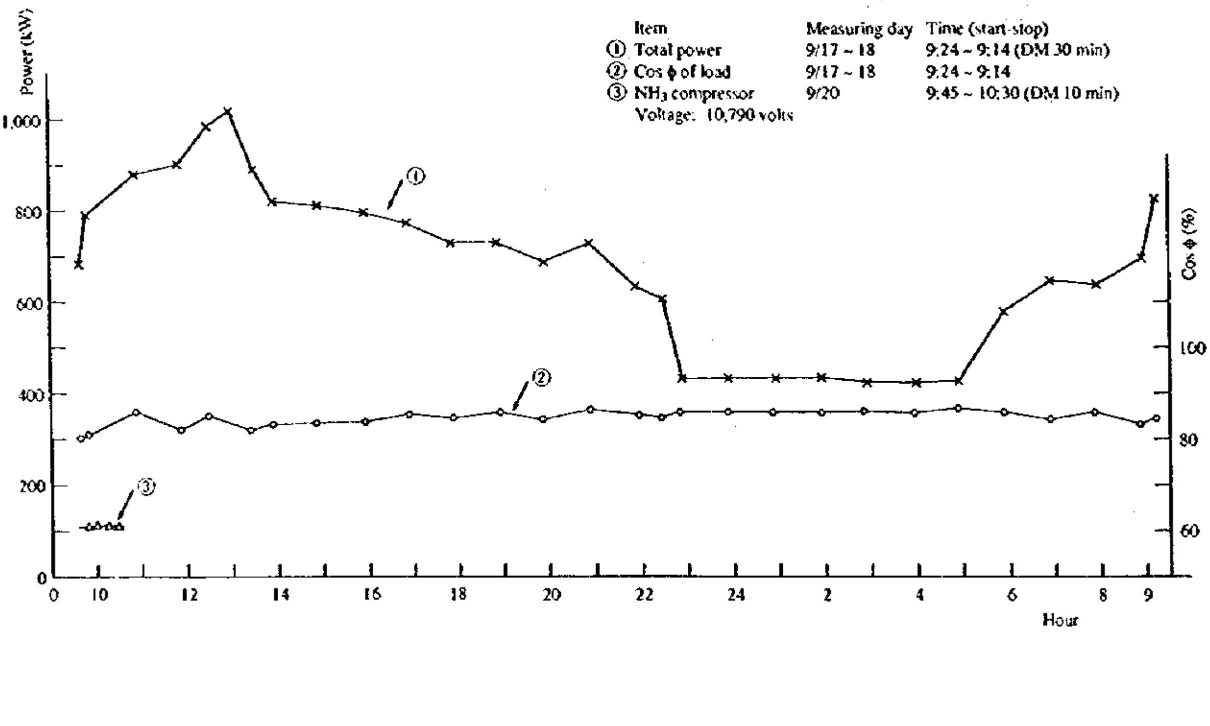
*: $11.33 \times 4 \times ((1{,}000 + 800)\ kW/2/0.85/4{,}000\ kVA)^2 = 3.18$ kW

**: $11.33 \times 3 \times ((1{,}000 + 800)\ kW/2/0.85/3{,}000\ kVA)^2 = 4.23$ kW

For the result of the actions against the demand, electricity used on an average in 1996 is presumed to be approximately 630 kW (= (4,481 MWh – 440 KWh × 4.5 h)/19.5 h/365 d). Therefore, the maximum demanded electricity is presumed to be 820 kW or lower in the normal plant. Thus, the present contracted electricity can be reduced to approximately 1,200 kW and annual saving will be approximately 5,688 PLN (= (1,350 – 1,200) kW × 3,16 PLN/ kW × 12 months).

Reduction of contract demand: 150 kW (= 1350 – 1,200)

Figure 5.3.8 Operation Record of Electricity Power Consumption



2) Reducing the electricity consumption for the cooling equipment

Electricity used for cooling in this factory is roughly equivalent to the electricity in production processes. However, since the cooling equipment run on a 24-hour basis, electricity used for cooling is larger than that for production processes. (See Figure 5.3.8.)

This means that, the cooling equipment occupies approximately 80 % of the electricity consumption. To cope with this situation, appropriate measures need to be immediately taken. The following measures are recommended:

Recommendable measures:

① Small-size and capacity equipment for the ammonia cooling equipment and salt water cooling equipment should be newly installed so that they can be used separately from the existing large-size equipment depending on the load status. (The small-capacity equipment should be used as often as possible.)

② Heat insulation for cooling piping should be repaired so that it will not be frosted. Frosting should also be prevented for the cooling portion in the factory.

③ The capacity of the chilled room should be reduced and full heat insulation should be applied. The entrance/exit door should be a double door and heat insulation should be applied to the inner walls.

④ Since the compressors are old, their efficiency should be examined. One new compressor at least should be installed if the examination result is not satisfactory.

Effect:

Quantitative evaluation for the measures ① to ④ is not available unless the operation status, size and structure of the cooling room, and so on are studied. However, according to the chilling energy intensity of this factory, electricity consumption on an average is 258 kWh/t (for processing plus butchery) and electricity consumed for cooling/chilling only is 382 kWh/t (465 kWh/t in the entire factory). These values imply that both energy intensity and costs can be reduced by taking the actions described above.

3) Motor load check and capacity optimization

About fifty motors (of 20 to 200 kW) are being used in this factory. Some of them are out of service, while motors in operation are light-loaded as shown in Table 5.3.18.

Table 5.3.18 Measurement Data of Major Load

September 18, 19, 1997

Transformer or Name of Load	Rating (kW, kVA)	Consumption (kW)	Voltage (V)	Power Factor (%)	Remark
Total load of 4 transformers	4,000	440 ~ 1,030	10,650	82 ~ 87	Recording
at 15:55, September 19		831	10,650	86	
No. 1 Substation No. 1 transformer	1,000	387	397	84	
Process of load	18 ~ 22	4	400	52	3 × motor
NH_3 No. 2 compressor	200	94	396	81	
NH_3 No. 2 compressor	160	134	393	96	
Pump of salt water	3 × 18.5	28	409	76	
NH_3 compressor		104	401	82	Record on September 20
Air compressor	3 × 18.5	22	401	83	
Substation No. 2 transformer	1,000	44	400	77	
No. 2 Substation transformer	1,000	310	398	96	
No. 3 Substation transformer	1,000	268	396	75	
Pump for cooling	3 × 30	39	398	88	
Boiler total		63	396		
Exhaust fan	18.5	12	400	76	
Pump of supply water	30	30	396	95	
Waste water process		21	399	76	
Killing of pig total		68	398	70	
Fan for killing pigs	3 × 15	14	393	82	
Well pump	4 × 55	35	395	71	1 operating
Pump for cooling tower	30	34	398	90	

Recommendable measures:

① If the motor is light-loaded compared with the rated capacity, it should be replaced with a small-capacity motor or an inverter should be installed for revolution control.

② Since some motors are overloaded, the motor load and power factor should be checked. The power factor of the light-loaded motor is often low. The degree of valve opening should also be the subject for consideration in checking the capacity of the fan, pump, etc.

Effect:

The effect of optimizing the motor capacity is relatively small because a new motor for replacement is expensive. However, the power factor is improved and the capacity of the related equipment can be reduced.

For the fan and pump, an inverter should be installed to control the motor revolution. This can produce a great electricity saving effect. For example, if the air flow rate is reduced by 20 %, approximately 40 % of electricity can be saved.

Electricity saving by variable speed control with an inverter unit:
(28 + 12 +21 + 35) × 0.4 × 8,760 h/y / 1,000 = 333 MWh/y

(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 5.3.19.

Table 5.3.19 Emission Improvement by Energy Conservation Measures

Measure	Reduction [ton/year]			
	CO_2	SO_2	NO_2	Dust
Step 0	794	5.5	1.5	1.2
Step 1	697	4.9	1.3	1.1
Step 2	781	5.5	1.5	1.2
Step 3				
Step 1-3	1,477	10.4	2.8	2.2

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 5.3.20. Furthermore, the payback period 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 5.3.20 Payback Period Improvement by Emission Fee Reduction

Measures	Energy cost advantage	Emission fee advantage	Total advantage	Investment	Eco-Environ PBP	Economical PBP
Step 0	208	2.5	210	2,057	9.77	9.89
Step 1	205	2.2	207	0	0.00	0.00
Step 2	280	2.5	282	1,701	6.02	6.08
Step 3						
Step 1-3	485	4.6	490	1,701	3.47	3.51

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

As evident from this Table 5.3.20, 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.

b. Summary of Energy Conservation Potential

The energy conservation potential of this factory is shown in Table 5.3.21.

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 5.3.9. The relationship between energy conservation potential, the period to recover the investment, and the investment cost is shown in Figure 5.3.10.

Table 5.3.21 Summary of Energy Conservation Potential

Electricity: 0.172 PLN/kWh Steam: 0.068 PLN/kg (2.75 GJ/t) 1 PLN = 30 yen

Item	Energy Conservation Potential							Investment	Payback period
	Fuel			Electricity			Total		
	GJ/y	10^3 PLN/y	%	MWh/y	10^3 PLN/y	%	10^3 PLN/y	10^3 PLN	year
Step 0 (Under planning)									
1. Recovering the waste heat through heat exchangers	8,409	208	15.0				208	2,057	9.9
Subtotal	8,409	208	15.0	0	0		208	2,057	9.9
Step 1									
2. Improving the boiler air ratio	6,244	154	11.1				154	0	0.0
3. Shutting down one transformer				9	2	0.2	1	0	0.0
4. Improving the yield	1,121	28	2.0	90	15	2.0	43	0	0.0
5. Controlling the electricity consumption at peak demand				150 kW	6		6	0	0.0
Subtotal	7,365	182	13.1	99	23	2.2	205	0	0.0
Step 2									
6. Improving the drain recovery rate in the heating process	5,606	139	10.0				139	1,029	7.4
7. Introducing the outside air				67	12	1.5	12	86	7.2
8. Providing a curtain at entrance and exit	561	14	1.0	45	8	1.0	22	103	4.7
9. Controlling the motors by an inverter				333	57	7.4	57	283	5.0
10. Insulating steam valves	2,071	51	3.7				51	201	3.9
Subtotal	8,238	204	14.7	445	77	9.9	281	1,701	6.1
Total (Steps 1 and 2)	15,603	386	27.8	544	100	12.1	486	1,701	3.5

As of 1996: Fuel consumption: 56,070 GJ/y
Electricity consumption: 4,481 MWh/y (45,957 GJ/y)
Total: 102,027 GJ/y

Figure 5.3.9 LUBMEAT Energy Conservation Potential

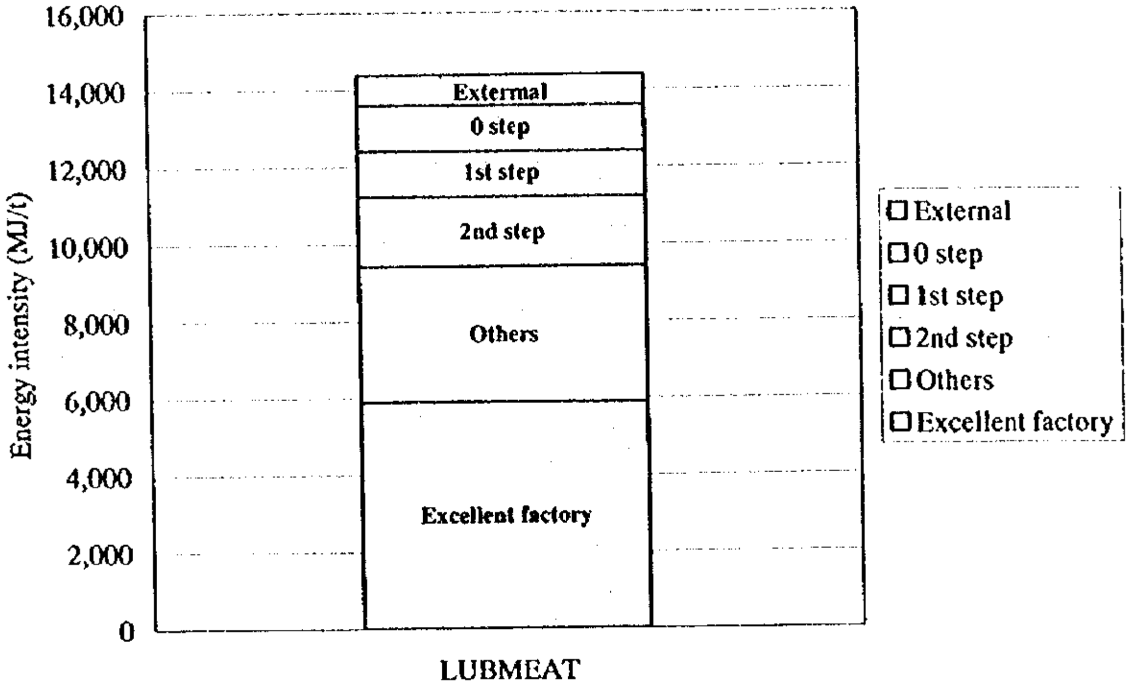
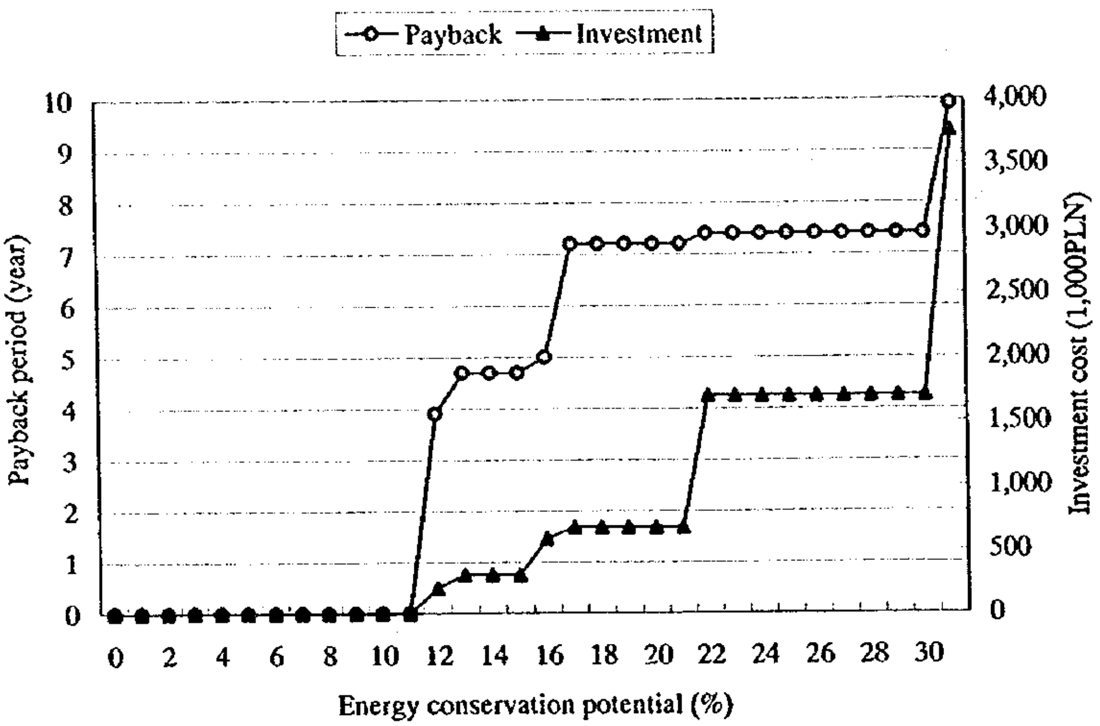


Figure 5.3.10 LUBMEAT Energy Conservation Potential



5.4 Results of the Study at the Obrzanska Dairy Plant

(1) Study period: September 8 and 9, 1997

(2) Members of the study team

a. JICA Team

Mr. Norio Fukushima : Leader of energy audit & Heat management
Mr. Shiro Honda : Process management
Mr. Jiro Konishi : Heat management
Mr. Toshio Sugimoto : Electricity management
Mr. Akihoro Koyamada: Measuring engineering

b. Local consultants

Research Center of Warsaw University of Technology
Dr. Krzysztof Wojdyga : Heat management
Mr. Maciej Chorzelski : Heat management
Mr. Stanislaw Kozinski : Electricity management

(3) Interviewees

Eng. Henryk Bendzinski : President
Eng. Boguslaw Majka : Technical Manager
Mr. Wojciech Rochowiak: Energy Manager
Mr. Nowak : Electrical Section
Mr. Czekiel : Electrical Section

5.4.1 Profile of the Plant

(1) Plant name: Obrzanska Dairy, Koscian

(2) Plant address: 64-000 Koscian ul, w, Maya 28, Poland

(3) No. of employees: 303

(4) Major products: Milk and butter

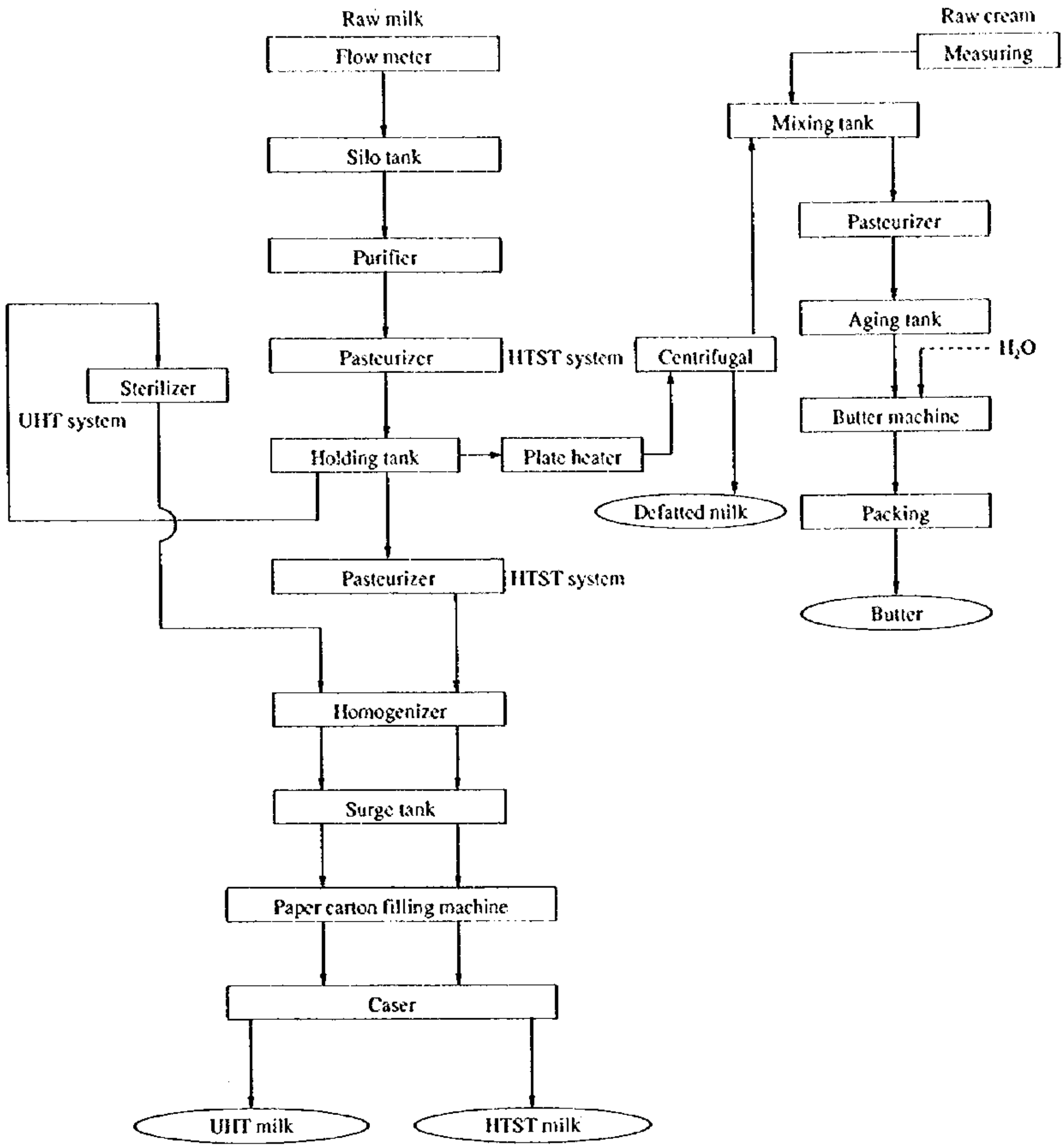
(5) Production capacity: 60 t/d

(6) Overview of process

50 % each of raw milk is collected from 200 procurement members and 1,800 small suppliers; it is then weighed, inspected, accepted, purified, sterilized, and stored for a time. Finally it is subjected to UHT setrilization processing and thereafter is packaged into tetra-packs and sold from its affiliated plants and network. Raw cream is received from another plant. After sterilization, cream is put in the butter machine and butter produced is packaged by a small packing machine as the product. According to the result in 1996, 94.5 % is milk and 5.5 % is butter. For steam, steam from this company's coal-fired boiler is used.

Since a cooperation warehouse is provided outside the factory, the stock in the factory is small. For chilling, the ammonia process compressor type refrigerating equipment is mainly used.

Figure 5.4.1 Process Flow

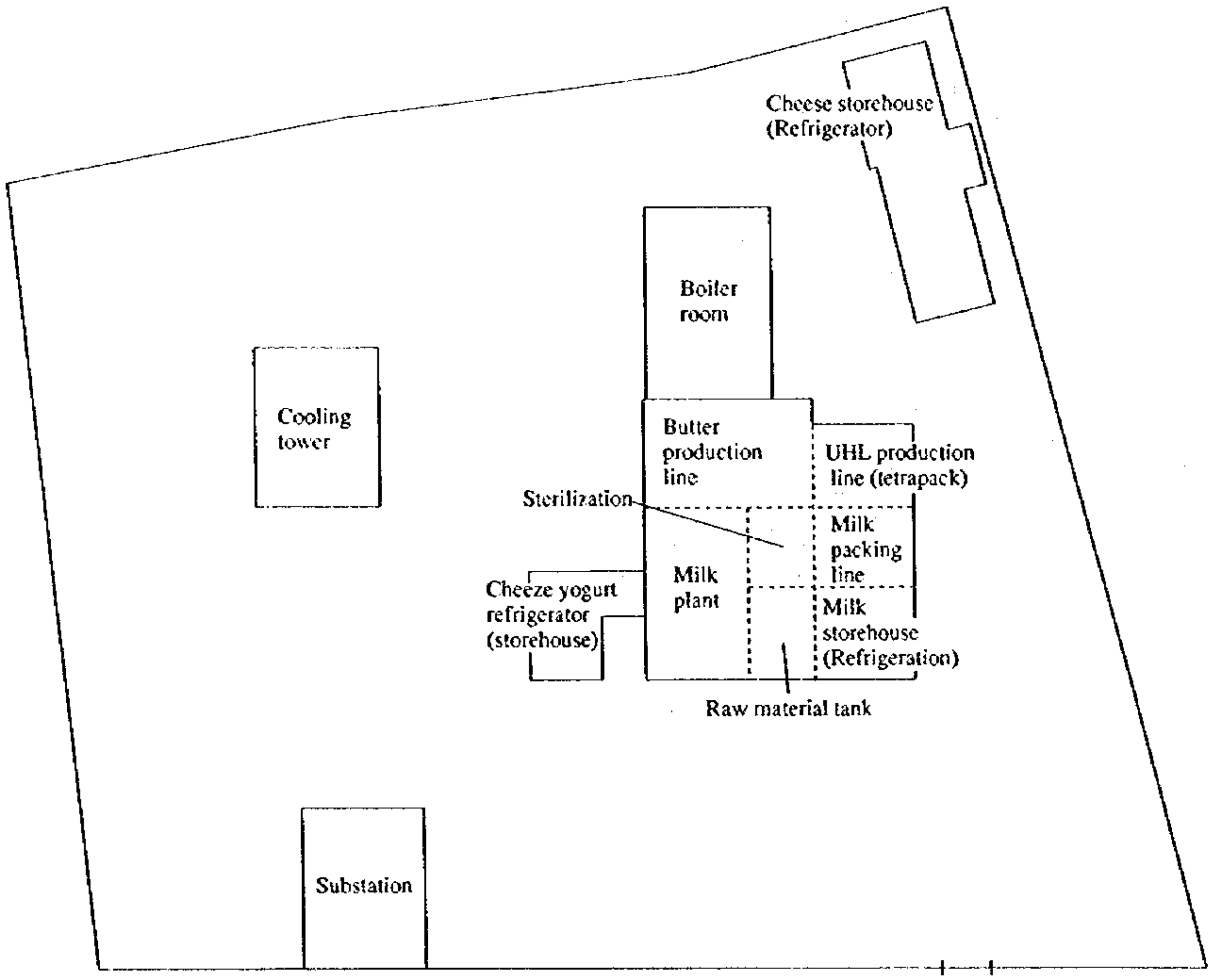


(7) History of this factory

This factory has a history of more than 100 years as a milk plant of the dairy cooperation. It is one of four dairy cooperation plants. The material is purchased from the community and the product is sold completely domestically and not exported. The building was constructed after the World War II and the management is positive for installation of energy conservation type facilities. A tetra-pack unit has been installed for the UHT milk plant and packing facility and addition of another tetra-pack unit is needed. Since the delivery base was established as a dairy cooperation, the stock in the company's own warehouse is small. Although this factory is charged with production of butter to process the surplus cream from other factories, the main product is milk.

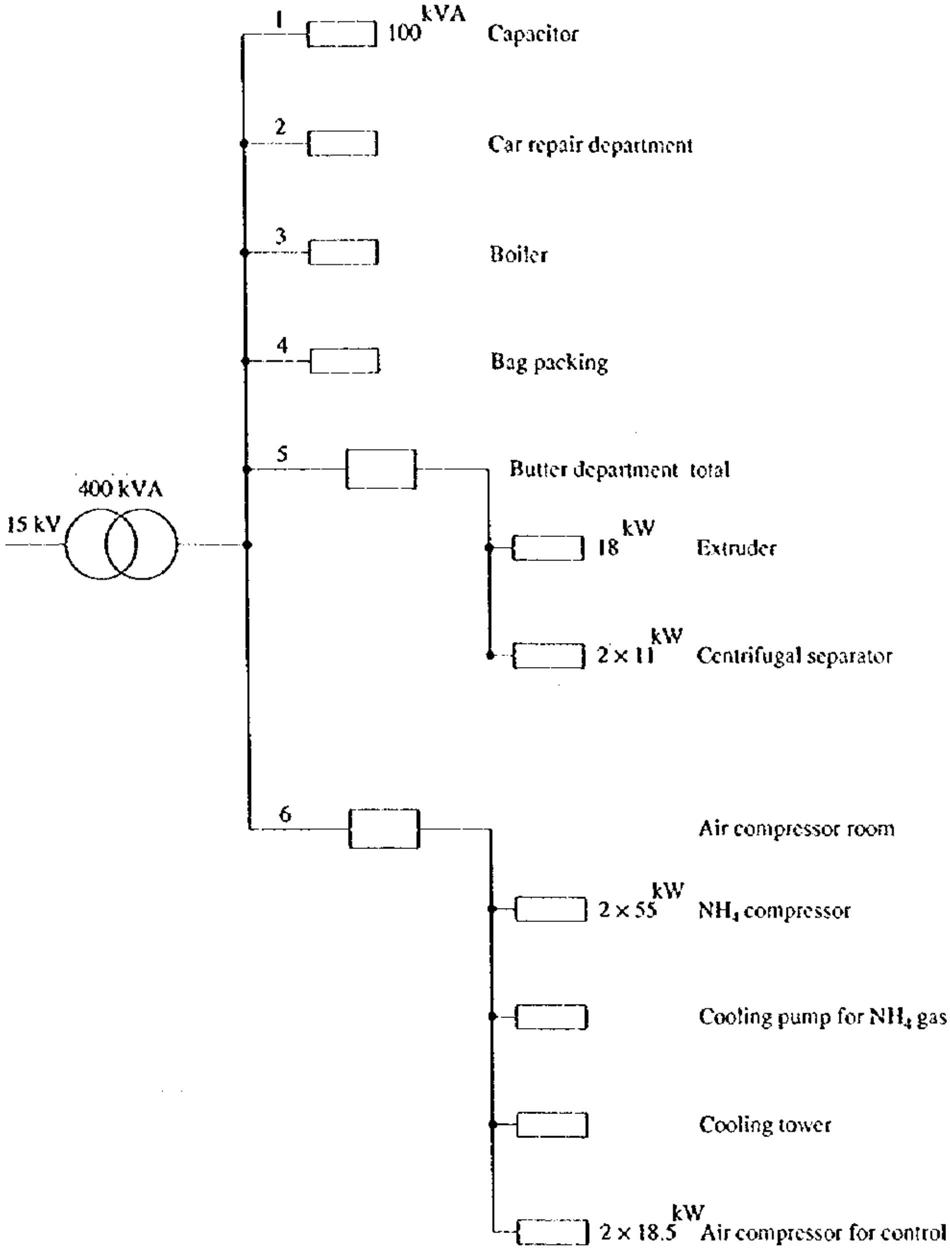
(8) Plant layout

Figure 5.4.2 Plant Layout



(9) One line diagram

Figure 5.4.3 One Line Diagram



(10) Outline of major equipment

Table 5.4.1 Major Equipment

Factory	Number	Specification
Milk		
Silo tank	6	10 $m^3 \times 4$ 16 $m^3 \times 2$
Purifier	1	7.5 kW 8,500 rpm
Sterilizer	1	UHT 145 – 150 °C 3 – 5 sec (design)
Pasteurizer	2	HTST 98 °C 20 sec (design)
Homogenizer	1	37 kW
Centrifugal	1	11 kW
Packing	2	5 kW
Butter		
Pasteurizer	1	HTST 98 °C 20 sec (design)
Extruder	1	18 kW Water contentw 16 % mixture 2,000 – 3,000 L/min
Compressor	4	55 kW × 2, 75 kW × 2, NH_4 type −18 °C
Pump	3	5.5 kW for NH_3
Air compressor	2	18.5 kW
Agitater	4	11 kW
Packing	2	7.5 kW, 4.5 kW
Boiler	2	2.2 t/h 191 °C 1.2 kg/cm^2 Coal

(11) Energy price and heat value

Table 5.4.2 Energy Price and Heat Value

	Energy price	Heat value
Coal	0.230 PLN/kg	29 GJ/t
Electricity	0.110 PLN/kWh	10.258 GJ/MWh

5.4.2 Energy Consumption Status

(1) Trend of production

Table 5.4.3 Trend of Production

Unit: t/y

	1992	1993	1994	1995	1996
Raw milk	12,736	16,603	17,802	19,516	23,146
Raw cream	784	568	574	461	562
Products					
Milk	5,093	5,123	9,552	11,137	12,960
Cream	30	445	286	10	31
Butter	556	578	544	512	760
Products total	5,675	6,146	10,382	11,659	13,751

(2) Trend of energy consumption

Table 5.4.4 Trend of Energy Consumption

	Unit	1992	1993	1994	1995	1996
Coal	t	780	1,050	1,020	1,324	1,323
Electricity	MWh	883	1,415	1,846	2,138	1,709

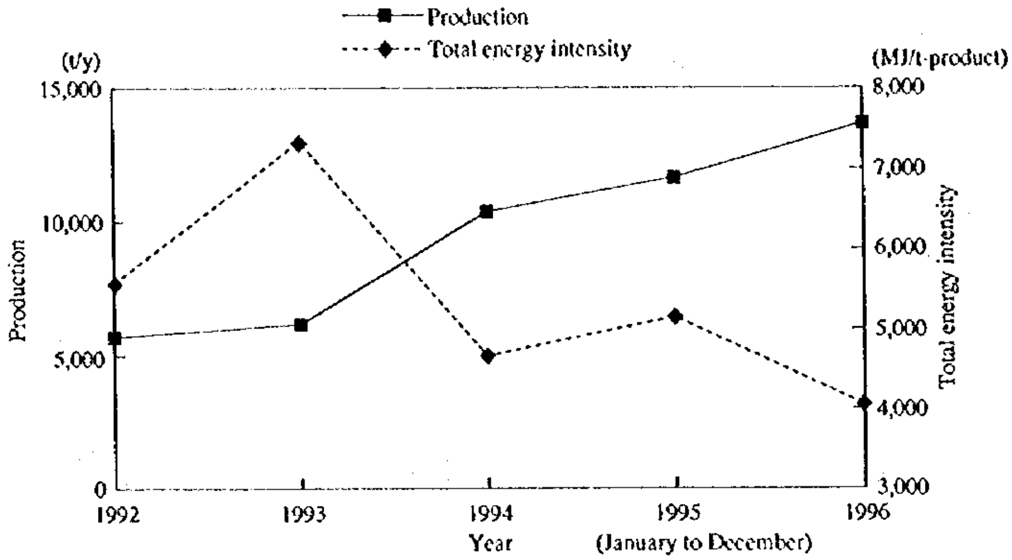
(3) Trend of energy consumption and intensity

Energy intensity has been increasingly improving.

Table 5.4.5 Trend of Energy Intensity

	Unit	1992	1993	1994	1995	1996
Consumption						
Coal	GJ	22,620	30,450	29,580	38,396	38,367
Electricity	GJ	9,056	14,512	18,933	21,927	17,528
Intensity						
Coal	MJ/t-product	3,986	4,954	2,849	3,293	2,790
Electricity	MJ/t-product	1,596	2,361	1,824	1,880	1,275
Total	MJ/t-product	5,582	7,315	4,673	5,173	4,065

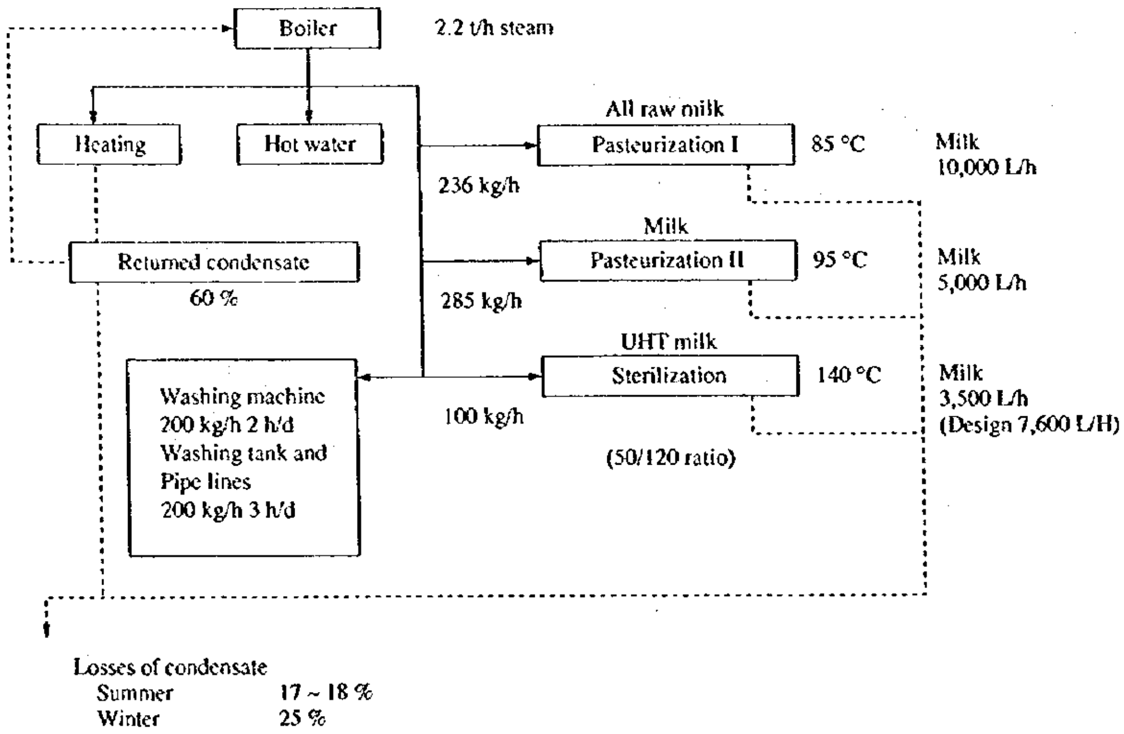
Figure 5.4.4 Trend of Production and Total Energy Intensity



The trend for 1993 and the subsequent years shows a steady growing production along with both coal and electricity intensity declining.

(4) Energy flow

Figure 5.4.5 Steam Balance



5.4.3 Setting up an Energy Conservation Target

(1) Setting an energy conservation target

a. Setting a target value

This plant consumes a large amount of coal, and there seems to be a room for energy conservation; however, no specific target has been set yet. A definite target needs to be set based on the data obtained.

b. Problems in promotion of energy conservation

While the management seems to provide guidance, the number of engineers who provide training and the number of measuring equipment are insufficient. The quality control level seems to be high.

(2) Systematic activities

a. Installation of a dedicated section for energy conservation

The dedicated section for energy conservation is not provided. Energy conservation technology should be acquired and more information should be collected.

b. Installation of an energy conservation committee

No committee for promotion of energy conservation is available. Some staff should be designated to promote energy conservation.

c. Management stance

The management is aggressive in cost reduction. It seems that the management have a good understanding of the actual status under the framework of the co-operation plants and they are showing positive attitude toward improvement of production, production equipment, and others through assistance among the plants.

(3) Data-based management

a. Grasping the energy consumption

Ledgers for production statistics and raw material are maintained well. Data on energy consumption can be obtained from the purchased amount.

b. Grasping the energy consumption by major facility

The energy intensity by product is not managed. No data on daily coal consumption and feed water volume are available, either. Therefore, they do not have an accurate grasp of energy consumption for each facility.

c. Installation of measuring equipment

The flow rate of steam and others, and temperatures, etc. of major facilities should be measured to know accurate energy consumption. This can enhance the accuracy of the specific measures to be taken for energy conservation. The measuring equipment should be installed in the future.

(4) Training of employees

It should be recognized that energy conservation leads to cost reduction and prevention of pollution. However, training does not seem to be positively performed.

(5) Plant engineering

Maintenance is relatively good. The plant site is not so large, and moverover repair operations are often performed, thus maintaining a clean operating environment. The management is positive for adoption of new models. They seem to enhance the tetra-pack facility and improve the chiller.

5.4.4 Problems and Countermeasures Related to Energy Use

(1) Comparison of the energy intensity with the excellent factory

Table 5.4.6 shows the result of comparing the energy intensity of Obrzanska with that of the excellent factory.

The atmospheric temperature in the region where Obrzanska is located is 5 °C lower than that in the location of the excellent factory on an annual average. The annual production scale of the excellent factory is 4.5 times larger than that of Obrzanska and the excellent factory produces beverages, cream, and dessert as well as milk (80 %). Also, the excellent factory circulates water for recycling.

Table 5.4.6 Comparison of Energy Intensity

	Unit	Obrzanska	Excellent Factory	Difference
Coal	kg/t	96.2	80	–
	MJ/t	2,790	2,320	470
Electricity	kWh/t	124	110	–
	MJ/t	1,272	1,128	144
Total	MJ/t	4,062	3,448	614

For prices, milk is 1.45 PLN/L and butter is 6.25 PLN/kg, which are cheaper than those in Japan. However, the electricity unit price and others are cheaper; hence no comparison is made here.

(for reference) Energy cost ratio to production cost

	Japan	Obrzanska
Fuel	0.50 %	1.65 %
Electricity	1.00	1.10
Total	1.50	2.75

(2) Estimating the energy conservation potential

(2)-1 Difference due to external factors

Major products of both Obrzanska and excellent factory are milk and cream. There is no energy intensity difference due to the material/product difference.

Although the effect of the outer air temperature is provided because of the location difference, Obrzanska performs heating in the office building only in winter. Therefore, presumably there is almost no energy intensity difference arising from heating.

Bacteria in the accepted material milk is around 10^4 pcs/mL in both cases, producing no difference. Nor is there any difference in sterilization conditions. For the fuel for the boiler, Obrzanska uses coal, while the excellent factory uses natural gas; therefore comparison is made in heat value.

For Obrzanska, as shown in Table 5.4.7, electricity consumption increases and coal consumption decreases in summer, while in winter coal consumption increases and electricity consumption decreases. The volume of water used has a large disparity but it increases in summer in accordance with electricity used.

Table 5.4.7 Monthly Energy Consumption

	Electricity (kWh)	Coal (t)	Water (m^3)
May 1996	87,699	90.0	7,009
June	98,699	77.5	7,423
July	111,458	87.5	8,658
August 1996	83,369	93.0	8,137
September	93,626	90.0	7,406
October	89,151	95.5	8,287
November	92,124	96.0	6,328
December	74,966	145.0	8,154
January 1997	103,099	124.0	6,232
February	90,154	99.7	6,796
March	72,710	84.3	6,590
April	105,207	102.3	8,237
May 1997	93,326	69.4	7,349
June	99,123	62.3	8,590
July	111,924	70.6	9,814

(2)-2 Difference due to technical factors

Energy conservation potential is divided into the following three steps to sort out its potential:

Step 1: Enhancing the management
Step 2: Improving the equipment
Step 3: Improving the processes

a. Process

1) Operation management of the sterilizing equipment

For the sterilization conditions for milk sold in the market, the UHT method (Ultra high temperature short-time sterilization method: 120 to 135 °C for 2 seconds) has been generally employed and produced satisfactory results from the standpoint of reducing the bacterial count as much as possible. However, milk stock control in dairy farms has been improved recently, drastically reducing the number of bacteria in milk. In addition, the chilled channels have been enhanced. These factors have triggered the recent emergence of milk products processed by the HTST method (high temperature short-time sterilization: 72 °C for 15 seconds) and LTLT method (63 °C for 30 minutes) for consumers who like natural food.

For milk production at Obrzanska, UHT milk production is growing as shown below.

The values in ( ) indicate the amounts processed by the UHT method and the percentages.

Year	Milk production	UHT milk production
1995	11,136 t	(551 t 5 %)
1996	12,960 t	(2,322 t 18 %)
1st half of 1997	8,739 t	(2,577 t 29 %)

As the equipment design capacity, 5,000 L/h HTST milk and 4,600 L/h UHT milk are to be made from the 1,000 L/h raw milk but the packing capacity consitutes a bottleneck.

By reducing the set temperatures in the UHT method and the HTST method to 135 °C and 72 °C respectively, the steam consumption can be decreased.

Strict management below bacteria number 10^5 pcs/mL should be performed so that the temperature set condition will meet the standard.

Table 5.4.8 shows comparison of steam consumption in the sterilization process.

Table 5.4.8 Comparison of Steam Consumption in Pasteurization Process

Unit	Pasteurization Temperature (°C)	Steam Consumption (kg/h)	Pasteurization Temperature (°C)	Steam Consumption (kg/h)
	Obrzanska		Excellent Factory	
HTST				
All raw milk	85	236		
2nd step	95	285		
Average	90	260	72	206*
	(4 → 90 °C)		(4 → 72 °C)	(21 % reduction)
	Δ86		Δ68	
UHT milk	140	100	135	96**
	(4 → 140 °C)		(4 → 135 °C)	(4 % reduction)
	Δ136		Δ131	

*: $260 \times (68/86) = 206$ kg/h

**: $100 \times (131/136) = 96$ kg/h

$(0.236 + 0.285) \times 0.21 + 0.100 \times 0.04 = 0.11$ t/h

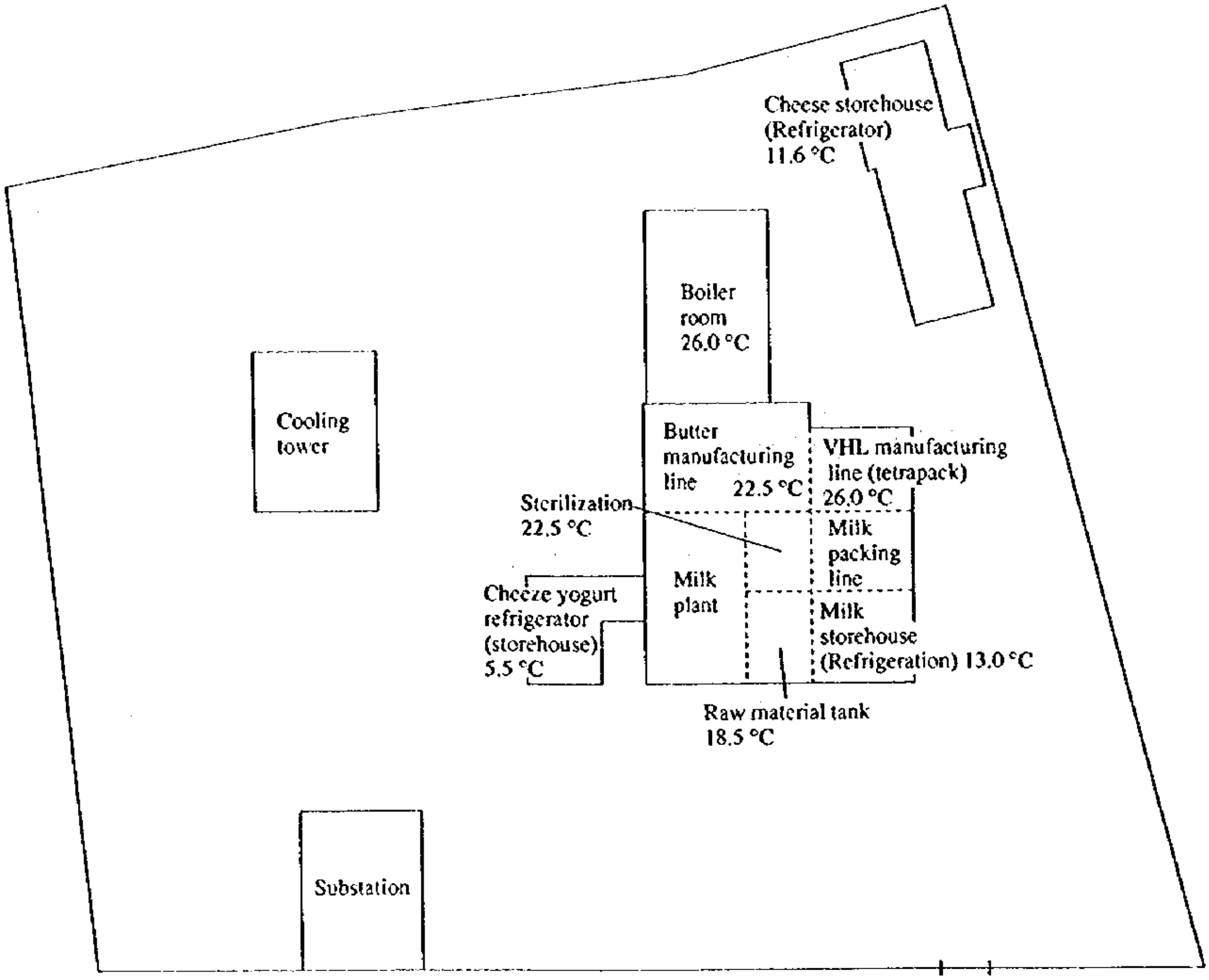
Therefore, 5 % of 2.2 t/h steam used can be saved.

Improvement in the fuel intensity: 2,790 MJ/t × 0.05 = 139 MJ/t (1,911 GJ/y)

2) Room temperature control

Figure 5.4.6 shows the room temperature distribution in the building.

Figure 5.4.6 Room Temperature Distribution



The cheese warehouse is controlled at 11.6 °C. They have a plan to transfer the storage of yogurt to the common warehouse of the cooperative. Currently, part of cheese and yogurt are both stored and controlled in the same storehouse at a temperature of 5.5 °C, which is too low for cheese.

The temperature of 13 °C at the entrance of the milk warehouse is considered to be adequate. A curtain is provided at the entrance of the milk warehouse to prevent the entry of outer air as a good practice.

An independent cooler is provided at the entrance of the milk plant and considered to be efficient. For cooling, intensive cooling and individual cooling are available. In a cold region, individual cooling can be shut down preferentially in winter, so that the load can be controlled easily.

8 coolers are located in the milk warehouse. Since they are operating at only 4 coolers even in summer, presumably all of them can be shut down in winter.

Based on the temperature of 11.6 °C in the cheese warehouse, the energy intensity can be improved by correcting overcooling in the cheese/yogurt warehouse: If electricity consumption corresponding to 11.6 – 5.5 = 6.1 °C is 2 kW, the following equation will be eatablished

2 kW × 4 months × 30 days × 24 hours = 5,760 kWh
10.258 MJ × 5,760 = 59 GJ/y
59 GJ/y/13,751 t = 4.29 MJ/t
Therefore, energy conservation of 0.3 % electricity to 1,272 MJ/t can be achieved.
Improvement in the electricity intensity: 4.29 MJ/t (0.418 kWh/t) (5.7 MWh/y)

3) Chiller operation management

The chiller uses 50 % of the entire electricity. 10 % is supposed to be used by pumps and blowers for air conditioning and cold water. The excellent factory performs total management. It shuts down the chiller and uses bacteria-free filters to utilize fresh-air in winter for air-temperature/temperature control. These means are accomplished by the systematic and scheduled energy conservation activities.

The energy conservation effect estimated on the assumption that this improvement will be applied to the Obrzanska factory will be as follows:

If 20 % of electricity for the chiller (50 %) can be reduced for the limited period of 4 months in winter, improvement in the energy intensity by utilizing the bacteria-free filter and fresh-air in winter will be:

1,272 MJ/t-product × 0.5 × 0.2 × 4/12 = 42 MJ/t-product (4.1 kWh/t)
(56 MWh/y)

4) Use of the empty warehouse

Since the co-operation common warehouse is constructed, the empty warehouse may be reused for production.

As a recommendable plan for use of this warehouse, installation of production equipment for yogurt which is increasingly demanded in Poland, or the laboratory for mixed coffee milk may be considered.

5) Improvement of milk

Recently, an enzyme that can decompose lactose in milk has been discovered. This enzyme, which is not a yeast, can decompose lactose only and is finding its way into some products in Japan. The enzyme, if only 0.2 to 0.4 g is added to 1,000 mL milk, exerts the effect; therefore its commercialization should be considered after being tested and examined.

6) Improving the equipment capacity

Improving the equipment capacity leads to the reduction of the fixed energy consumption rate such as heating, thus producing an effect in terms of energy intensity. It is important for energy conservation to improve the production capacity including the development of new products.

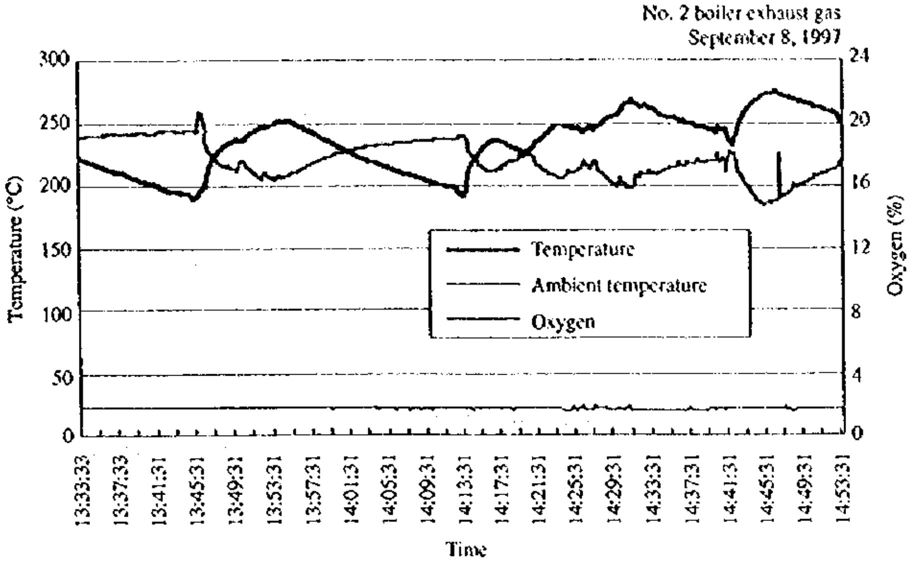
It is also advisable to consider and plan the research and development of the cooperating organization.

b. Utilities (heat utilizaition facility)

1) Improvement of air ratio of the boilers

This factory has two boilers for use in production processes and heating. The exhaust gas from the No. 2 boiler that was running was measured in the underground flue below the outdoor smokestack. Figure 5.4.7 shows the result.

Figure 5.4.7 Boiler (No. 2) Exhaust Gas Measurement



As shown in Table 5.4.9, this is the boiler using manually fired coal, and the oxygen content in the exhaust gas is at a high level. As a result of calculating combustion according to the average of the measured values of oxygen in the exhaust gas in Figure 5.4.7, the air ratio is 6 as shown in Table 5.4.9. In other words, air volume six times larger than that required for theoretical combustion is introduced into the boiler.

Table 5.4.9 Air Ratio Obtained by Exhaust Gas Measurement

Preconditions

Coal	
Net heat value (kJ/kg)	29,711
Net heat value (kcal/kg)	7,098
Ash content	5.70 %
Water content	6.00 %
Combustion air temperature	22.2
Exhaust gas temperature	233.8

Note: Measurement was conducted at the flue in front of the smoke stack.

Calculation Result

	Theoretical Combustion	Current AR Condition	After AR Improvement
Exhaust gas oxygen	0.0 %	17.6 %	14.8 %
Air ratio	1.00	6.04	3.34
Air flow rate (m^3/kg)	7.3	43.9	24.3
Exhaust gas volume (m^3/kg)	7.7	44.3	24.7
Exhaust gas heat loss rate (to combustion heat)		42.4 %	23.9 %
Fuel reduction rate			24.3 %

Note: The oxygen content after air ratio improvement indicates the minimum of the measured O_2 values.

If air is adjusted so that oxygen content in the exhaust gas will be minimal (14.8 %) (air ratio: 3.3), fuel will be reduced by 24 % as shown in Table 5.4.9 according to calculation. (in the summer season only)

The coal consumption in the summer accounts for 20 % of the annual consumption.

Therefore the reduction in energy intensity will be as follows:

1,323 t × 0.2 × 0.24 × 29 GJ/t ÷ 13,751 = 0.134 GJ/t (1,842 GJ/y)

In Figure 5.4.7, it seems that oxygen in the exhaust gas is reversely correlated with the exhaust gas temperature, which is shown in Figure 5.4.8. Combustion becomes very active and oxygen content in the exhaust gas reduces immediately after coal is charged. However, along with the elapse of time after charging, combustion slows down and air becomes excessive. As a result, oxygen content in the exhaust gas increases. This means that supply of too much cold air is implemented and makes the exhaust gas temperature drop. It is necessary to adjust the air volume as coal combustion proceeds.

Figure 5.4.8 No. 2 Boiler Exhaust Gas

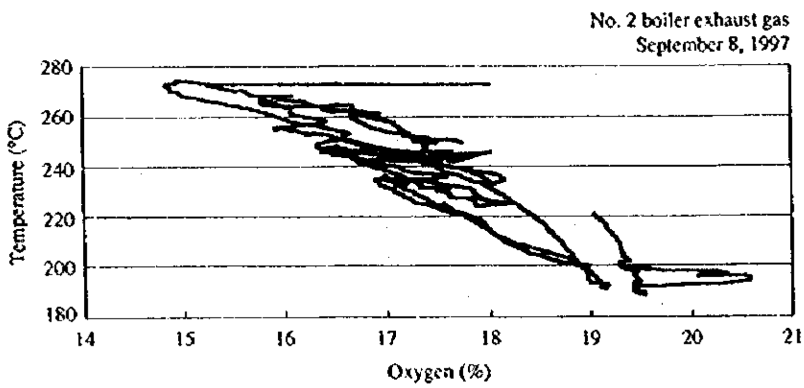


Table 5.4.10 shows the components of coal used for this calculation.

Table 5.4.10 Boiler Coal Composition

C	H	O	N	S	Water Content	Ash Content
81.5 %	4.9 %	11.4 %	1.3 %	1.1 %	6.0 %	5.7 %

Table 5.4.11 shows the outline of this boiler.

Table 5.4.11 Steam Boiler

No. of units	2
Year of installation	No. 1: 1986, No. 2: 1928
Type	Lancasha type (2 flues/boiler)
Maker	Fakop, Sosnowiec (Poland), Model P-100/12
Pressure and temperature	1.2 MPa, 191 °C (Saturated)
Evaporation amount, Heating area	2.2 t/h, Boiler water storage: 28.9 m³, Heat area: 100 m²
Fuel, combustion system	Coal (29,000 kJ/kg), Manual firing (2 charging hole/boiler)
Air flow	Natural drafting during operation; power-actuated FDF is available for starting the cold boiler.
Feedwater treatment equipment	Softener used together for processing, to supply soft water and cold water
Dust collector	Not available
Operating hours	Always one boiler operating, 16 h/d

2) Reinforcement of heat insulation

In this factory, heat insulation is not applied to the steam valves in the boiler room and production process room. Assuming the number of installed valves estimated based on the survey result, heat loss from these steam valves is calculated. Table 5.4.12 shows the result.

Table 5.4.12 Calculation of Heat Radiation

Installation Place	Environmental Temperature (°C)	Surface Temperature (°C)	Nominal Diameter (mm)	Equivalent Length (m)	Assumed No. of Units Installed	Heat Loss (kcal/h)
Header in the boiler room	27.9	170.0	200	3	1	4,345
Steam valve in the boiler	27.9	170.0	50	1.28	10	5,185
Steam valve in the boiler	27.9	170.0	80	1.56	2	1,861
Steam valve in the boiler	27.9	170.0	100	1.58	4	4,837
Steam valve in the factory	27.9	170.0	50	1.74	20	9,060
Steam valve in the factory	26.0	170.0	25	1.21	50	8,852
Total						34,141

If heat insulaition is applied to the steam valves, heat radiation can be reduced to approximately 10 %. In this factory a large amount of cooling water is also used in production processes.

Similarly, cold insulation is required for the cold water pipe and tank for processing to prevent a temperature rise.

However, the temperature difference from cold water is smaller and therefore, its heat absorption is smaller than steam.

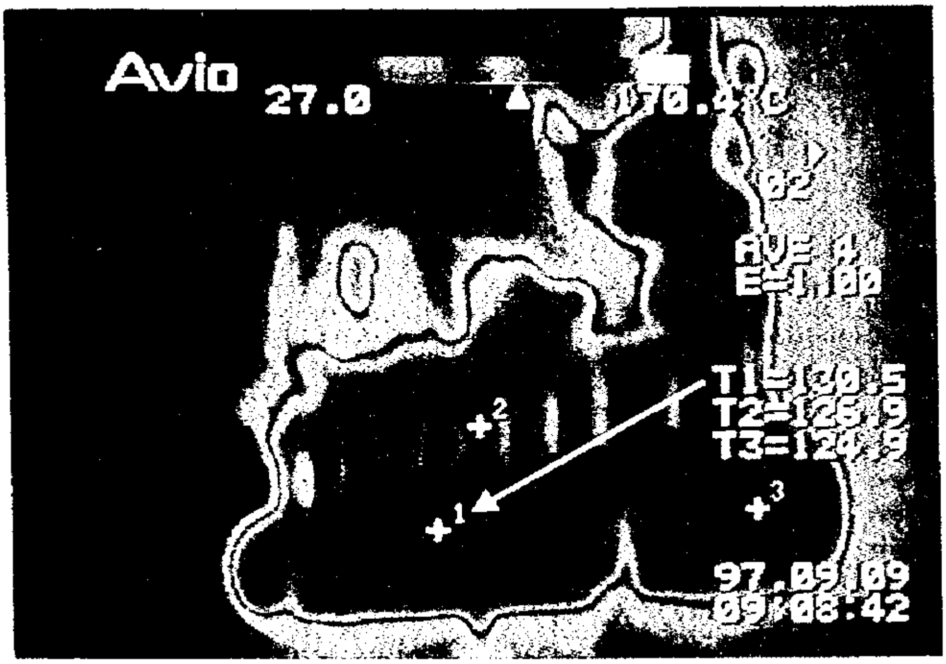
In this section, therefore, only the effect stemming from the reduction of heat emission loss is calculated as shown below.

Operation time: 5,840 h/y in 1995
Steam saving : 34,141 × 4.1868 × 0.9 × 5,840/1,000,000 = 751 GJ/y
When boiler efficiency is 75 %,
Fuel saving : 751/0.75 = 1,000 GJ/y

3) Thermal image of the valve without heat insulation

By taking a photograph of the high-temperature portion to which heat insulation is not applied by using an infrared thermal imaging system the high temperature at this portion can be visually represented as image colors. For reference, Figure 5.4.9 shows the infrared thermal image of the steam header portion in the boiler room.

Figure 5.4.9 Infrared Thermal Image of the Steam Header

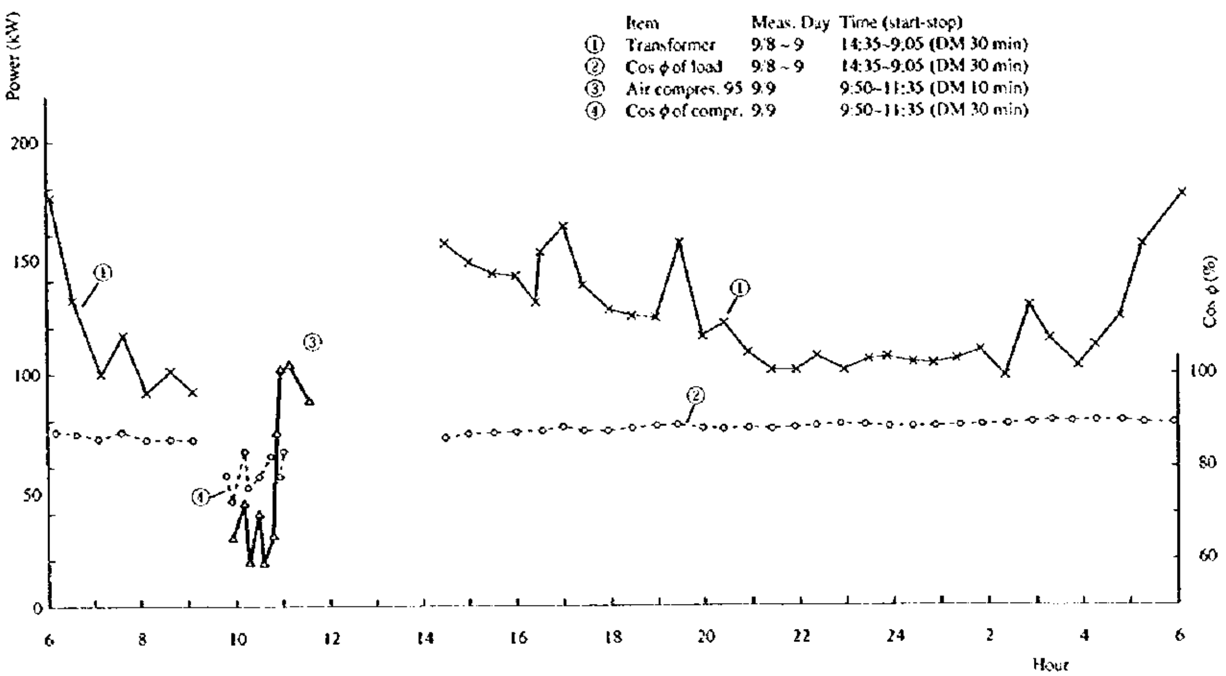


c. Utilities (electricity utilization facility)

1) Peak electricity suppression

As a result of measuring the receiving electricity continuously, it is found that the power factor is 85 %, which may be satisfactory (see Figure 5.4.10) but electricity used reaches the peak. (At 16:00 on September 8 and around 5:30 on September 9, the peak electricity which was 1.4 to 1.6 times larger than electricity used occurred.) This is presumably because it may be associated with the shift time. Electricity consumption by the chiller during this measurement was 80 % of entire electricity.

Figure 5.4.10 Operation Record of Electricity Power Consumption



Recommendable measures:
The peak should be suppressed by shifting the operation starting time.

Effect:
The electricity cost is reduced by suppressing the demand. Therefore, it is important to shift the work starting time.
The annual average electricity used in 1996 was approximately 200 kW (= 1,079 MWh/5,840 h); thus the maximum electricity demand is presumed to be 260 kW or below. Therefore, the current contract (318 kW) is estimated to be reduced by 18 kW or more, allowing an annual reduction of approximately 3,694 PLN. (= 18 kW × (0.0901 + 17.0235) PLN/kW × 12 months)

Contract demand reduction: 18 kW

2) Energy conservation for the air compressor

The current on-load rate (operation time (on load)/full operation time) of the air compressor is approximately 30 %, which is low. Fortunately, the compressor is so managed as to stop a certain time after unloading but an electricity loss occurs before this stop. The compressors in this factory consume electricity of approximately 10 kW during the unloading time.

According to the current operation status, the load for control and operation is smaller on saturdays and sundays, so it is assumed that the compressors' use rate further reduces. Therefore, the following measures are recommended:

Recommendable measures:

① Small compressors for a small load should be installed when the load is small on saturdays and sundays and after the operation is over.

② Additionally, the air pressure reduction valve should be installed at a place as close to the equipment using air as possible. To reduce the delivery air pressure of the compressor, the pressure loss from the piping should be minimized. Also, air leak should be checked on a regular basis to prevent air leak immediately if it is found.

Effect:
Since the machine availability is improved if small-capacity machines are used, machine idle operation can be reduced. Also, electricity used decreases and the loss is reduced.
Air leak prevention and air pressure reduction will lead to electricity saving.

3) Energy conservation for the ammonia type chiller unit

This refrigerating equipment consists of the compressor, cooling tower, cooling water feed pump, and cooling water stirring pump. Electricity consumption in the process is approximately 50 % or more of entire electricity consumption.

Presently, the machine is run according to the operator's sense, and thus wastes, such as overcooling and unnecessary pump operation are considered to occur. Therefore, the following action is important:

Action:
The temperature of cooling water should be measured by a thermometer and the temperature control criteria should be determined. If the temperature is out of the criteria, an alarm should be issued and the valve, etc. should be operated to make adjustment. Automatic operation is preferred if possible.

Effect:
Generally, operation according to the operator's sense results in waste of energy. Although this wasteful energy consumption will be reduced through implementation of the above-mentioned measure, quantitative presumption is impossible in the current status.

(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 5.4.13.

Table 5.4.13 Emission Improvement by Energy Conservation Measures

Measure	Reduction [ton/year]			
	CO_2	SO_2	NO_2	Dust
Step 0				
Step 1	354	2.5	0.7	0.5
Step 2	95	0.7	0.2	0.1
Step 3				
Step 1-3	449	3.2	0.8	0.7

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 5.4.14. Furthermore, the payback period 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 5.4.14 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	29	1.1	30	0	0.00	0.00
Step 2	16	0.3	16	80	5.05	5.15
Step 3						
Step 1-3	45	1.4	46	80	1.73	1.79

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

As evident from this Table 5.7.14, 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 payback period is also negligible.

This factory supplies steam from coal-fired boilers, and therefore energy conservation through the reduction of steam consumption leads to a reduction in coal consumption. Since coal emits a larger amount of pollutant than gas fuels, the emission fee per unit of heating value becomes larger. The ratio of emission fee to the fuel cost is 3 % in Step 1 and 2.1 % in Step 2. The reduction in this emission fee has improved the investment recovery.

b. Summary of Energy Conservation Potential

The energy conservation potential of this factory is shown in Table 5.4.15.

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 5.4.11. The relationship between energy conservation potential, the payback period, and the investment cost is shown in Figure 5.4.12.

Table 5.4.15 Summary of Energy Conservation Potential

Coal: 170 PLN/t (29 GJ/t) Electricity: 0.172 PLN/kWh 1 PLN = 30 yen

Item	Energy Conservation Potential							Investment	Payback period
	Fuel			Electricity			Total		
	GJ/y	10^3 PLN/y	%	MWh/y	10^3 PLN/y	%	10^3 PLN/y	10^3 PLN	year
Step 1									
1. Controlling the operation of the sterilization equipment	1,911	11	5.0				11	0	0.0
2. Controlling the room temperature				6	1	0.4	1	0	0.0
3. Improving the air ratio of boilers	1,842	11	4.8				11	0	0.0
4. Controlling the peak demand				18 kW	6		6	0	0.0
Subtotal	3,753	22	9.8	6	7	0.4	29	0	0.0
Step 2									
5. Controlling the chiller operation				56	10	3.3	10	51	5.3
6. Insulating the steam valves	1,000	6	2.6				6	29	4.9
Subtotal	1,000	6	2.6	56	10	3.3	15	80	5.2
Total	4,753	28	12.4	62	17	3.63	45	80	1.8

As of 1996: Fuel consumption: 38,367 GJ/y
Electricity consumption: 1,709 MWh/y (17,528 GJ/y)
Total: 55,895 GJ/y

Figure 5.4.11 Obzrzanska Energy Conservation Potential

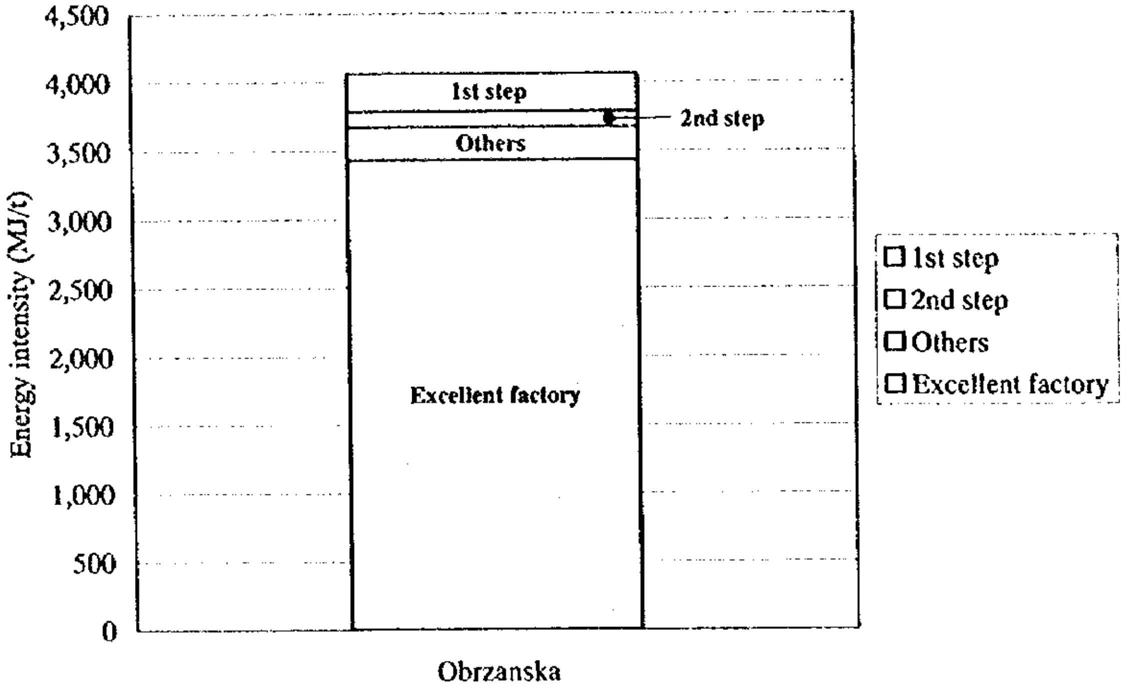


Figure 5.4.12 Obrzanska Energy Conservation Potential