8. RESULTS OF FACTORY AUDIT

8. RESULTS OF FACTORY AUDITS

The results of energy auditing at each factory and the appropriate energy conservation measures derived from the audit results were recommended to the management staff and engineers at the factories. For the last two days of the seven auditing days, experts in process (JICA team) provided man to man technical guidance to factory engineers (regarding energy management methods based on the audit results, the details of improvement technologies for each step).

8.1 The Current Energy Consumption Situation at Factories

For the purposes of obtaining an accurate picture of the energy use situation in Polish industry and of promoting energy conservation at factories, the JICA's study team conducted 3-day simple audits at 12 factories in 1997 and 7-day detailed audits at 5 factories in 1998. A total of 15 different factories were surveyed, at two of which both simple and detailed audits were conducted, while simple or detailed audit was conducted at the other factories. The data obtained through these audits and other survey methods enabled the team to grasp the actual energy use situation in Poland and estimate the country's energy conservation potential. Table 8.1 shows the energy use situation at the 15 factories, comparison of the energy intensity in the surveyed factories with that in the excellent factory of the same industrial sector, and the recommendations for energy conservation measures. Among the energy conservation measures shown in the table, those classified as step 1 and step 2 include the improvement of energy management and the improvement of equipment, respectively, while those classified as step 3 include changes to processes involving large-scale investment.

The energy conservation potential of each factory is represented in graphs. As shown in Figure 8.1, the energy intensity at the excellent factory is between 40 % and 60 % of the energy intensity of the Polish factories. It follows that Polish factories have an average energy conservation potential of 50 %.

As shown in Table 8.1, energy savings of between 13 % and 28 % can be achieved by strengthening the management of energy use and the implementation of an improvement project based on recovery of investment within 3 years. Moreover, while the monetary amount invested in the improvement of equipment would differ from one industry to another, and would also differ between different factories in the same industry owing to differences of scale, it would be within the range of 70 thousand PLN and 10 million PLN per factory.

Table 8.1 Energy Intensity Levels in Polish Factories, Energy Conservation Effect and Investment Payback Period

Industrial sectors	Iron and steel making	Chemicals	Machinery	Non-metallic materials	Food processing
Comparison of energy intensity levels Figures obtained by dividing the energy intensity of the excellent factory by that of the average factory in Poland	0.62	0.46	0.42	0.42	0.57
Energy conservation effect of energy management improvement and the equipment improvement project based on the payback period within 3 years. (Reduction rate in energy consumption [%])	16.7 %	28.5 %	17 %	21.3 %	13.1 %
Investment amount per factory in monetary terms with the payback period within 3 years (1,000 PLN)	10,260	1,870	3,100	3,230	70

The current status of energy consumption in each factory is described below.

Table 8.2 Summary of Energy Audit in Selected Factories (1/5)

No.	Factory name	Location Period	Products Production	Heat consumption	Electricity consumption MWh/y	Energy intensive equipment	Energy conservation 1st and 2nd measure	Energy conservation 3rd measure
A.	Steel-making industry							
1	Huta Labedy Energy intensity Labedy: 4,238 MJ/t Japan: 2,626 MJ/t	Gliwice 7/25-7/29, '97	Shaped steel 209,358 t/y Flat plate 28,564 t/y in 1996	Natural gas 18.176 km^3/y	36,940	1)Rolling mill reheating furnace 2)Rolling mill motor	1) Production control 2) Improvement of yield 3) Waste heat recovery 4) R. f'ce air ratio control 5) Insulation 6) Lighting: Sodium lamp 7) Control of air compressor	1) Hot charge rolling 2) Centralizing of the mill
2	Huta Ostrowiec Energy intensity Factory overall Ostrowiec: 15,351 MJ/t Japan: 9,199 MJ/t Steel bar Ostrowiec: 12,080 MJ/t Japan: 7,128 MJ/t Forged steel Ostrowiec: 38,202 MJ/t Japan: 22,088 MJ/t	Ostrowiec 7/30-8/1, '97	Steel bar 507,932 t/y Forged steel 41,829 t/y in 1996	Natural gas 83,395 km^3/y Hot water 321,917 GJ/y Steem 133,984 GJ/y	624,829	1) Arc furnace 2) Ladle furnace 3) Rolling mill reheating furnace 4) Forging heating furnace 5) Blower 6) Pump	1) Arc f'ce short tap-to-tap 2) Ladle f'ce stop 3) Improvement of yield 4) Waste heat recovery 5) Furnace air ratio control 6) Insulation reiforcement 7) Ceramic fiber insulation 8) Arc f'ce blower operation 9) Lighting: Sodium lamp 10) Control of pump	1) Hot charge rolling 2) Exhaust gas boiler 3) heat recovery of arc f'ce
3	Lacznikow Energy intensity Lacznikow: 57,511 MJ/t Japan: 36,593 MJ/t	Radom 10/16-10/24, '98	Pipe fittings 9,544 t/y in 1997	Coke 5,333 t/y Heavy oil 172.8 kL/y Coal 3,250 t/y	27,963	1) Cupola 2)Heat treatment furnace 3)Boiler 4)Zinc plating 5)Space heating	1) Insulation of heat treatment furance 2)2-Zn coating line operation 3)Improvement of yield 4)Low air ratio of boiler 5)Reduction of air leakage	1)Installation of holding furnace 2)Improvement of cupola 3)Fuel conversion of heat treat-ment furnace by Natural gas

Table 8.2 Summary of Energy Audit in Selected Factories (2／5)

No.	Factory name	Location Period	Products Production	Heat consumption	Electricity consumption MWh/y	Energy intensive equipment	Energy conservation 1st and 2nd measure	Energy conservation 3rd measure
B.	Chemical industry							
4	Blachownia Energy intensity Tar distillation Brachownia: 2,853 MJ/t Japan: 944 MJ/t Benzen distillation Brachownia: 5,245 MJ/t Japan: 2,578 MJ/t Ethylbenzen synthesis Brachownia: 4,334 MJ/t Japan: 14 MJ/t	Szkolna 8/27-8/29, '97	Tar 90,993 t/y Benzene 65,838 t/y Ethyl benzene 56,490 t/y Bisphenol-A 8,433 t/y Polyethylene 16,959 t/y in 1996	Coke oven gas 8,798 km^3/y Steam 1,767 TJ/y	70,623	1) Steam ejector 2) Heating f'ce 3) Distillation tower	1)Improvement of air ratio of f'ce 2) Insulation reinforcing 3) Reduction of air leakage 4) Reduction of steam of ejector 5) Heat recovery 6) Lighting: Sodium lamp 7) Reduction of peak demand	
5	POCH Energy intensity Poch: 129 MJ/t - Process:: 63 MJ/t - Heating: 66 MJ/t Japan: 34 MJ/t	Gliwice 8/18-8/20, '97	Reagent 775 t/y Industrial acid 507 t/y Others 713 t/y in 1996	Natural gas 125 km^3/y Coal 11,374 t/y City gas 134 km^3/y	4,941	1) Boiler	1) Yield improvement 2) Improvement of boiler air ratio 3) Insulation 4) Increase of steam trap 5) Reduction of transformer capa. 6) Lighting: Sodiium lamp	
6	BORUTA Energy intensity Boruta: 114 MJ/t Japan: 59 MJ/t	Zgierz 10/8-10/16, '98	Dyestuff 2,187 t/y in 1997	Steam 219,519 GJ/y	4,733	1)Spray dryer 2)Air compressor 3)Ice making unit 4)Space heating	1)Replacement of heat exchanger of spray dryer 2)Improvement of window glass 3)improvement of steam line 4)Improvement of lighting	1)Installation of new spray dryer 2)Introduction of automation of material charging

Table 8.2 Summary of Energy Audit in Selected Factories (3/5)

No.	Factory name	Location Period	Products Production	Heat consumption	Electricity consumption MWh/y	Energy intensive equipment	Energy conservation 1st and 2nd measure	Energy conservation 3rd measure
C.	Machine manufacture industry							
7	URSUS Energy intensity URSUS: 140 GJ/Tractor - Process: 76GJ/Tractor - Heating: 64GJ/Tractor Japan: 45 GJ/Tractor	Warsaw 7/21-7/23, '97 9/30-10/8, '98	Tracter 14,501 trc/y in 1997 16,718 trc/y in 1996	Natural gas 8,049 km^3/y Coal 25,057 t/y	114,087	1) Boiler 2) Cupola 3) Air compressor 4)space heating	1)Promotion of energy conser-vation awareness (HOPP) 2)Introduction of batch production 3)Reduction of air leakage 4)lowering of air pressure 5)Introduction of inverter	1)Modernization of engine machine shop
8	STAR Energy intensity STAR: 221 GJ/Truck - Process: 119GJ/Truck - Heating: 102GJ/Truck Japan: 29 GJ/truck	Starachowice 8/4-8/6, '97	Truck 3,200 trc/y in 1996	Natural gas 251 km^3/y Heat 458,187 GJ/y	23,573	1) Heat treatment furnace 2) Compressor	1) Improvement of space heating 2) Control of drying furnace 3) Reduction of air pressure 4) Improvement of compressor 5) Arrangement of transformer 6) Reduction of peak demand	1) Improvement of yield 2) Modernization of machine line

Table 8.2 Summary of Energy Audit in Selected Factories (4/5)

No.	Factory name	Location Period	Products Production	Heat consumption	Electricity consumption MWh/y	Energy intensive equipment	Energy conservation 1st and 2nd measure	Energy conservation 3rd measure
D.	Non-metalic mineral industry							
9	Wolomin Energy intensity Bottle Wolomin: 26.7 GJ/t Japan: 11.2 GJ/t Hard Boro Silicate Wolomin: 161.9 GJ/t Japan: 131.6 GJ/t	Warsaw 8/12–8/14, '97 9/14–9/22, '98	Bottle glass 18,551 t/y Other glass 3,071 t/y in 1997 Bottle glass 20,320 t/y Other glass 2,689 t/y in 1996	Natural gas 20,963 km^3/y Coal 1,774 t/y	19,380	1) Melting furnace 2) Compressor	1) Melting f'ce air ratio 2) Melting f'ce insulation 3) Melting f'ce heat recovery 4) Yield improvement 5)Reduction of peak load 6)Lowering of air pressure	1)Reconstruction of melting furnace 2)Modification of melting f'ce
10	SILIKATY Energy intensity SILIKATY: 1.68 GJ/t Japan: 0.72 GJ/t	Radom 8/22–8/26, '97	Silica lime block 49,306 t/y in 1996	Coal 2,857 t/y	663	1) Boiler 2) Autoclave 3) Blower	1) Autoclave operation pattern 2) Condennsate recovery 3) Improvement of boiler air ratio 4) Insulation reinforcement 5) Improvement of mixing line 6) Reduction of peak load 7) Lighting: Sodium lamp	

Table 8.2 Summary of Energy Audit in Selected Factories (5／5)

No.	Factory name	Location Period	Products Production	Heat consumption	Electricity consumption MWh/y	Energy intensive equipment	Energy conservation 1st and 2nd measure	Energy conservation 3rd measure
E.	Food processing industry							
11	OLVIT Energy intensity OLVIT: 5,150 MJ/t Japan: 2,703 MJ/t	Gdansk 9/11-9/15, '97	Refined oil 12,749 t/y Hydrogenated oil: 14,169 t/y Margarine 26,940 t/y Total 53,858 t/y in 1996	Fuel oil 359 t/y Steam 55, 553 t/y	10,070	1) Deodrizer 2) Hydrogen plant	1) Reduction of heat loss of deodorizer 2) Control of steam pressure of ejector 3) Improvement of hydrogenation filter 4) Improvement of heat method of deodorizer 5) Insulation reinforcement 6) Reduction of peak demand	1) Reduction of reaction time of hydrogenation reactor
12	Koscian meat Energy intensity Koscian: 8,407 MJ/t Japan: 4,238 MJ/t	Koscian 9/4-9/5, '97	Pork Ham, Sausage 9,190 t/y in 1996	Natural gas 1,739 km^3/y	2,650	1)Boiler 2)Compressor	1) Installation of curtain 2) Condensate recovery 3) Insulation reinforcement 4) Introducing of fresh air 5) Improvement of chiller 6) Lighting: sodium lamp	
13	LUBMEAT Energy intensity LUBMEAT: 14,379 MJ/t Japan: 5,895 MJ/t	Lublin 9/17-9/19, '97	Pork, Beef Ham, Sausage 7,096 t/y in 1996	Steam 20,389 t/y	4,481	1)Compressor	1) Waste heat recovery 2) Improvement of boiler air ratio 3) Improvement of yield 4) Insulation reiforcement 5) Introduction of fresh air 6) Shutdown of a transformer	
14	Obrzanska dairy Energy intensity Obrzanska: 4,062 MJ/t Japan: 3,448 MJ/t	Koscian 9/8-9/9, '97	Milk, Butter Cheese 13,751 t/y in 1996	Coal 1,323 t/y	1,709	1)Boiler 2)Chillar	1) Boiler air ratio control 2) Insulation reinforcement 3) Control of sterilzation temp. 4) Control of chiller operation 5) Reduction of peak demand	
15	MLECZ Energy intensity MLECZ: 9.00 GJ/t Japan: 5.10 GJ/t	Wolsztyn 9/22-9/30, '98	Liquid milk 9,880 t/y Powder milk 4,190 t/y Butter 1,380 t/y Chees & other 4,240 t/y in 1997	Steam 134,399 GJ/t	5,085	1)Boiler 2)Chillar 3)Spray dryer	1)Improvement of sanitary condition 2)Improvement of aeration sys-tem in waste water treatment 3)Reduction of waste water volume 4)Cleaning of boiler air heater 5)Replacement of steam pipe 6)Insulation of steam line	1)Replacement of coal boiler by gas boiler 2) Replacement of steam ejector by vacuum pump 3)Installation of Gas co-generation system

8.1.1 Iron and Steel Making Industry

The survey covered the Ostrowiec steel mill with the fourth largest production capacity in Poland, the Labedy steel mill that rolls shaped steel, and the Lacznikow factory that manufactures cast iron pipe fittings.

(1) Labedy steel mill

Labedy has a history of 85 years. In 1996, the steel making division and bar mill division were separated through adoption of the joint corporation system with external funds. Presently, this company simply rolls shaped steel and small plates, and manufactures steel support (mining beam and cramp). Labedy supplies utilities such as natural gas, electricity, industrial water, etc. to the joint companies (ELSTAL and FERROPOL) located on the same premises.

a. Energy management status

The heating furnace for rolling bar steel is equipped with a combustion control with a micro computer, and a monitor device. However, no exhaust gas oxygen content detector is available, and only furnace heat control is performed. Thus for energy conservation, the control system should further be improved. The bar mill and plate mill are both simple facilities, and their energy intensities are therefore relatively low. In 1997 step 0 measures, such as abolishment of the large bar mill and heat recovery from cooling water for the electrical furnace, were implemented. As a result, the energy intensity was improved by 15 %

b. Energy conservation potential

The energy intensity in 1996 was 4,238 MJ/t, which shows that it has a 38 % energy conservation potential if 2,626 MJ/t of the excellent factory is used as the benchmark. Enhancement of energy management and investment for facility improvement based on the payback period within 3 years is estimated to achieve a 30 % energy saving.

Step 1 energy conservation measures

Measures recommended include improvement of the rolling load for the middle size shaped steel mill, setting of heat holding standards for the heating furnace at the plate steel mill, and improvement of rolling performance. It is estimated that these measures can achieve savings of 8 % in fuel and 5% in electricity.

Step 2 energy conservation measures

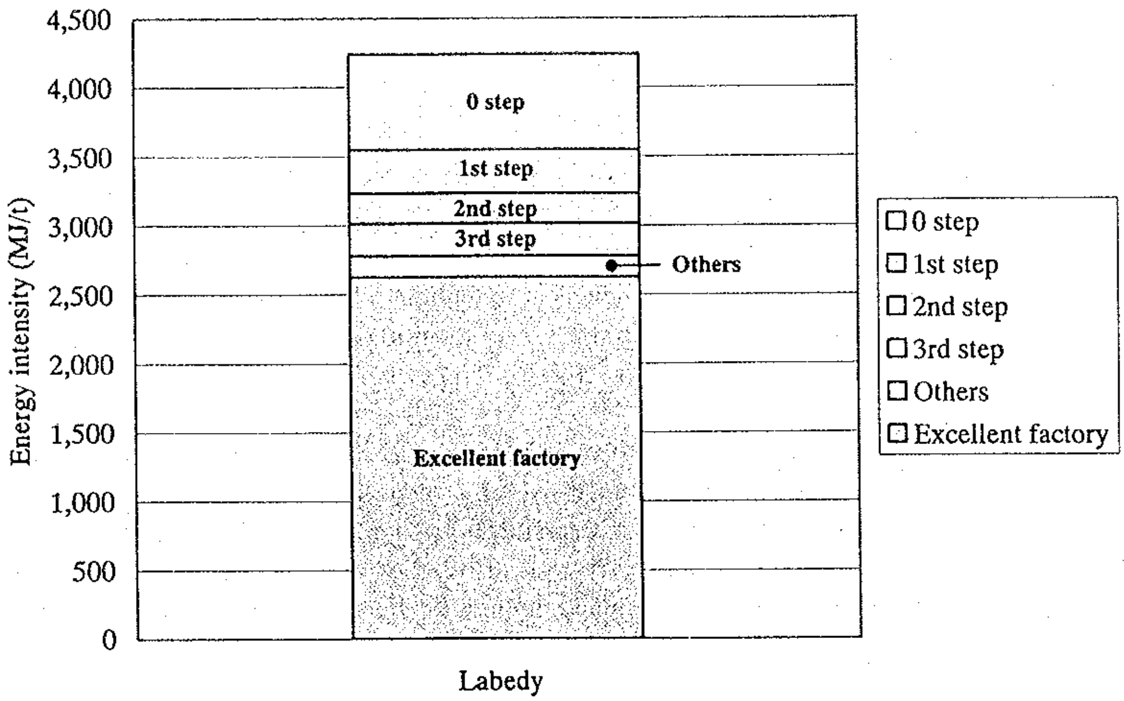
Measures recommended include reinforcement of the heat insulation of the heating furnaces at the middle-size shaped steel mill and plate steel mill, by the use of ceramic fiber, enhancement of electricity-saving for the cooling water system, improvement of lighting, and improvement of operation control methods of the air compressor. These measures are estimated to achieve savings of 3.1 % in fuel and 8.4 % in electricity.

Step 3 energy conservation measures

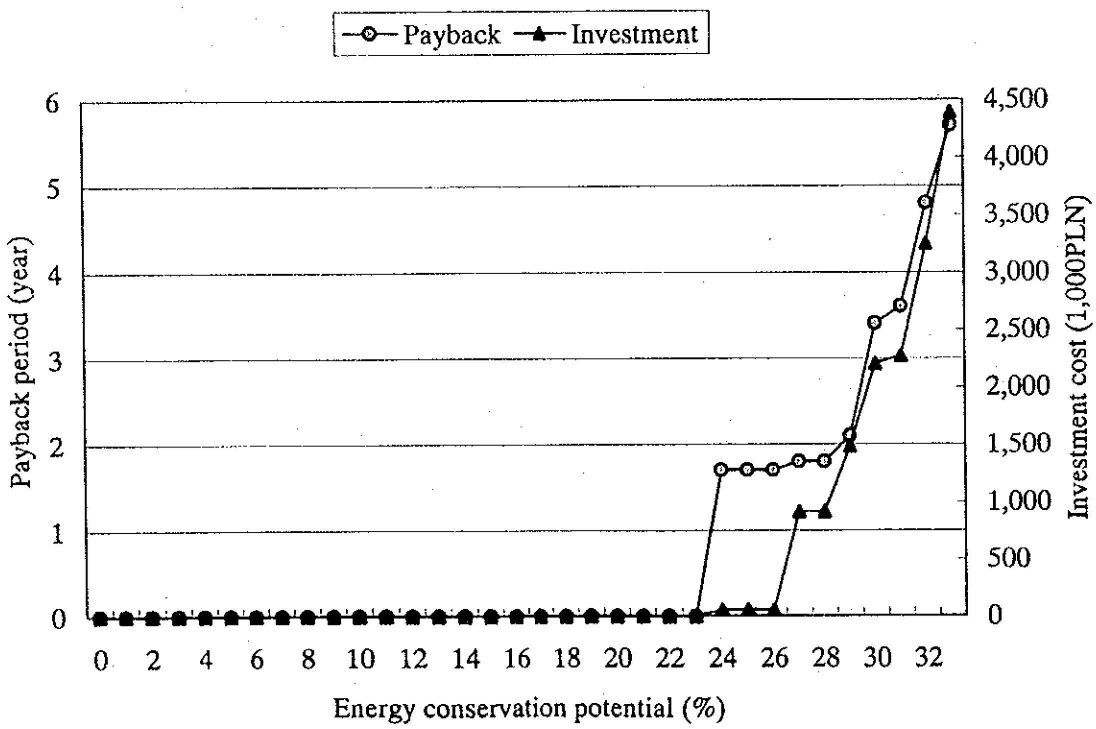
Measures recommented include introduction of hot charge rolling in the middle-size shaped steel mill and centralization of the mills through review of the layout. These measures are estimated to achieve savings of 8.3 % in fuel.

If improvement of the reheating furnace for rolling and hot charge rolling are implemented, the energy intensity will be equivalent to that of the excellent factory. The implementation of hot charge rolling requires large investment, collaboration with joint corporation ELSTAL, and distribution management. It is thus recommended that they should be determined through the business administration strategy.

Labedy Energy Conservation Potential



Labedy Energy Conservation Potential



(2) Ostrowiec Steel Mill

This steel mill is equipped with a large 140-ton electrical furnace, bloom continuous casting equipment, a full-continuous bar mill and a forging mill. Its production capacity is 600 thousand ton of irregular-shape bar steel/year and 50 thousand ton of forged steel per year. However, production is not growing because of the insufficient continuous casting capacity. In 1997, construction of the billet continuous casting equipment and the reheating furnace for bloom in the rolling equipment and shutdown of the blooming rolling mill were started.

a. Energy management status

Energy conservation measures such as construction of billet continuous casting equipment, and the use of ceramic fiber for the forge-heating furnace are being implemented.
A production management system capable of coping with fluctuations in production volume has not been established, thus resulting in a large energy loss for the entire factory.

b. Energy conservation potential

The energy intensity in 1996 was 15,351 MJ/t, which indicates that this steel mill has a 40 % energy conservation potential if 9,199 MJ/t of the excellent factory is used as the benchmark. By enhancement of energy management and investment for facility improvement which can be recovered within 3 years, a 24 % energy saving can presumably be achieved.

Step 1 Energy Conservation Measures

Recommended measures include reduction of the tap-to-tap time of the 140-ton steel-making electric furnace, improvement of the air ratios of the rolling and forge-heating furnaces, and lowering of the ratio of misrolling in the rolling process. It is estimated that these measures can achieve savings of 16 % in fuel and 4.5 % in electricity.

Step 2 Energy Conservation Measures

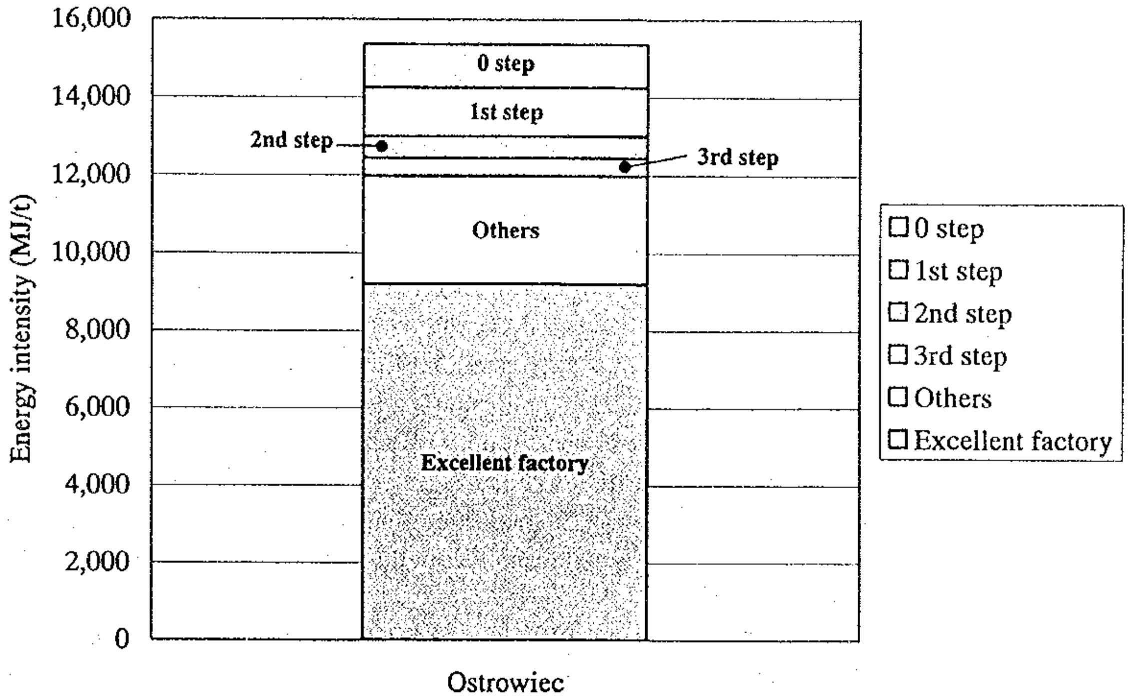
Measures recommended include the installation of scrap pre-heating equipment in the 140-ton steel-making electric furnace, and reinforcement of heat insulation in the rolling and forge-heating furnaces by the use of ceramic fiber. It is estimated that these measures can lead to savings of 5 % in fuel and 3.5 % in electricity.

Step 3 Energy Conservation Measures

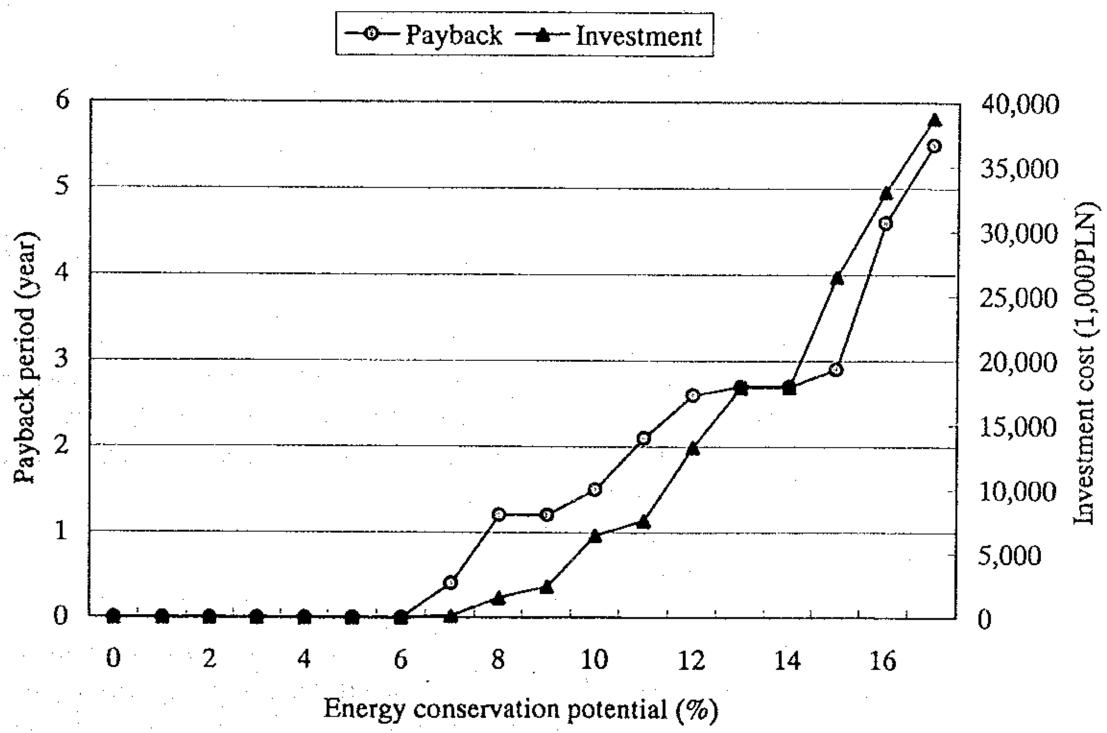
Improvement of the hot charge rolling rate of the rolling mill and use of an exhaust gas boiler for the electric furnace are recommended. These measures are estimated to achieve a saving of 9.5 % in fuel.

Important improvement projects include those related to the improvement of the heating furnaces in the forging mill and hot charge rolling in the rolling process.

Ostrowiec Energy Conservation Potential



Ostrowiec Energy Conservation Potential



(3) Factory of Lacznikow

Lacznikow, located in Radom city, is a cast iron factory that manufactures malleable cast iron pipe fittings. Molten metal of 10,000 t/year is produced through alternate operation of two cupolas. The share of its products in the Polant market is more than 90 %. The company, currently state-owned, is to be privatized in 1999.

a. Energy management status

The president and company executives are concerned about cost reduction and promotion of energy conservation. An improvement proposal system has been implemented, and as a result, once a year, every employee proposes an improvement on productivity, quality, and energy conservation. The adopted program is awarded by the president. Activities for reduction of the electricity intensity are in progress. Electricity meters are attached to the factory's principal machinery, and a system for the collection of data has been set up. They at the factory are actively engaged in energy conservation for lighting. During the course of observing the recent survey, the staff in charge of energy management became acquainted with the methods of analysis and utilization of data, and the method of measuring the amount of leakage of compressed air.
Positive energy conservation effort is currently being made through the implementation of hot blasting for the cupolas, use of 5 heat treatment furnaces for operation, adoption of an automatic thread cutting device, etc.

b. Energy conservation potential

The energy intensity in 1997 was 57,500 MJ/t, indicating that this factory has a 36 % energy conservation potential if 36,600 MJ/t of the excellent factory is used as the benchmark. Through enhancement of energy management and investment for facility improvement based on the payback period within 3 years, a 29 % energy saving is estimated to be achieved.

Step 1 Energy Conservation Measures

It is estimated that savings of 9 % in fuel and 6 % in electricity can be achieved by the use of 24-hour-a-day operation (in three shifts) of the cupola, with a once-a-week furnace-change system, improvement of the productivity of the heat treatment furnace, improvement of the air ratios of the boilers, and a reduction in the amount of compressed air leakage.

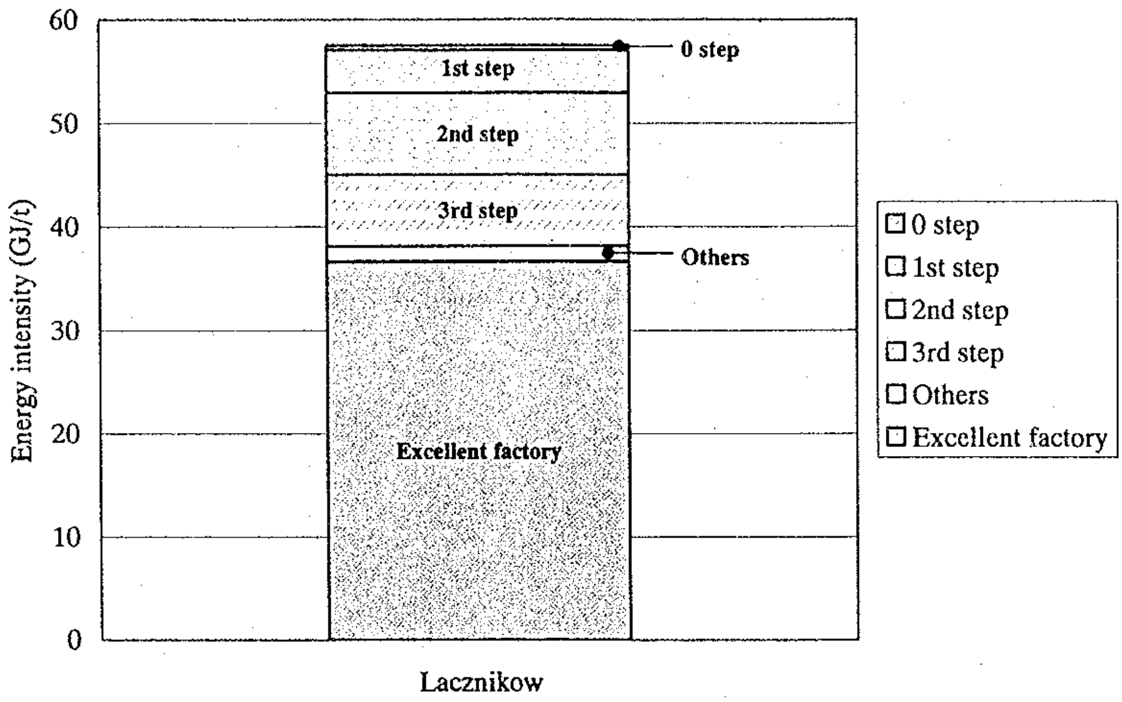
Step 2 Energy Conservation Measures

Fuel consumption can be reduced by 25 % and electric power consumption by 3 % by replacing the cupola fore-hearth with an induction heat furnace, injecting powdered coke through tuyeres, using an oxygen enrichment process, and employing two molten zinc baths.

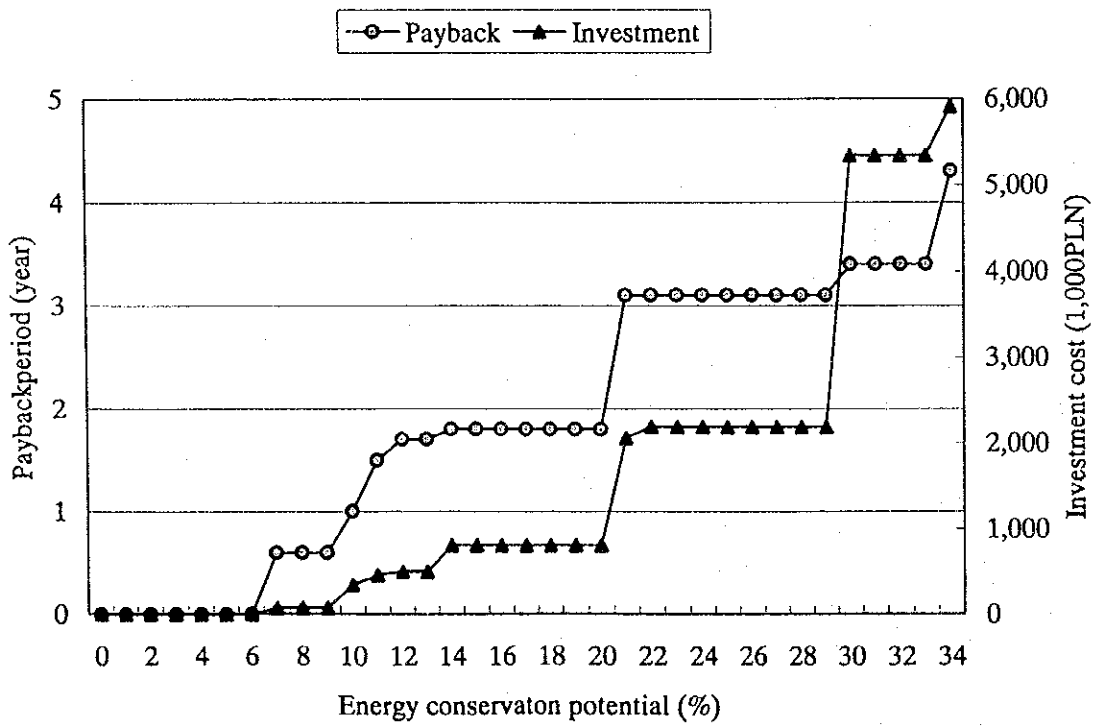
Step 3 Energy Conservation Measures

Savings of 33 % in electric power consumption can be achieved by replacing the present electric heat-processing furnace with a gas-burning radiant tube type burner and automating the cast mould manufacturing process at the casting mill. Full consideration has been given to the feasibility of replacing the cupola with an induction heat furnace, but from the viewpoint of energy cost, it is deemed more advisable to fit the present cupola with a supplementary induction heat furnace. From the standpoint of environmental protection measures and management strategy, priority should be assigned to the implementation of the improvement projects such as improving the method of heating used in the heat treatment furnace, improving the drying method used in the galvanizing process, and replacing compressors with new models.

Lacznikow Energy Conservation Potential



Lacznikow Energy Conservation Potential



8.1.2 Chemical Industry

The survey covered three factories, that is, POCH, the only chemical reagent company in Poland, Brachownia manufacturing ethylbenzene, polyethylene, bisphenol A, etc., and Boruta manufacturing chemical dyes.

(1) Factory of Brachownia

Brachownia planned a chemical industrial complex in its wide site (560 ha) but it is currently interrupted. Presently, facilities for manufacturing distilled tar, ethylbenzene, and polyethylene are dispersely located in the wide site. Utility facilities for such as electricity, compressed air, and hot water have some allowance. Restructuring for efficiency improvement such as promotion of outsourcing the processes and introduction of companies to the vacant space is being planned.

a. Energy management status

Brachownia supplies compressed air, steam, and hot water from the utility center to each factory far away, thus resulting in a large amount of energy distribution loss. The volumes of compressed air, steam, and hot water used in each factory are not measured, hampering the smooth implementation of energy management.
It will be efficient to combine and install manufacture of ethylbenzene production equipment using exothermic reaction and styrene monomer production equipment using endothermic reaction. This was included in the initial plan but has not been realized because the styrene monomer facility was not adopted.

b. Energy conservation potential

The energy intensity of the tar distilling facility in 1996 was 2,853 MJ/t, indicating that the factory has a 67 % energy conservation potential if 944 MJ/t of the excellent factory is used as the benchmark. Enhancement of energy management and investment for facility improvement based on the payback period within 3 years is estimated to achieve a 34 % energy saving.

Step 1 energy conservation measures

Recommended measures include improvement of air ratio of the tar heating furnace, reduction of compressed air leakage, and reinforcement of the heat insulation of the distillation column. These measures are estimated to achieve savings of 11 % in fuel and 12 % in electricity.

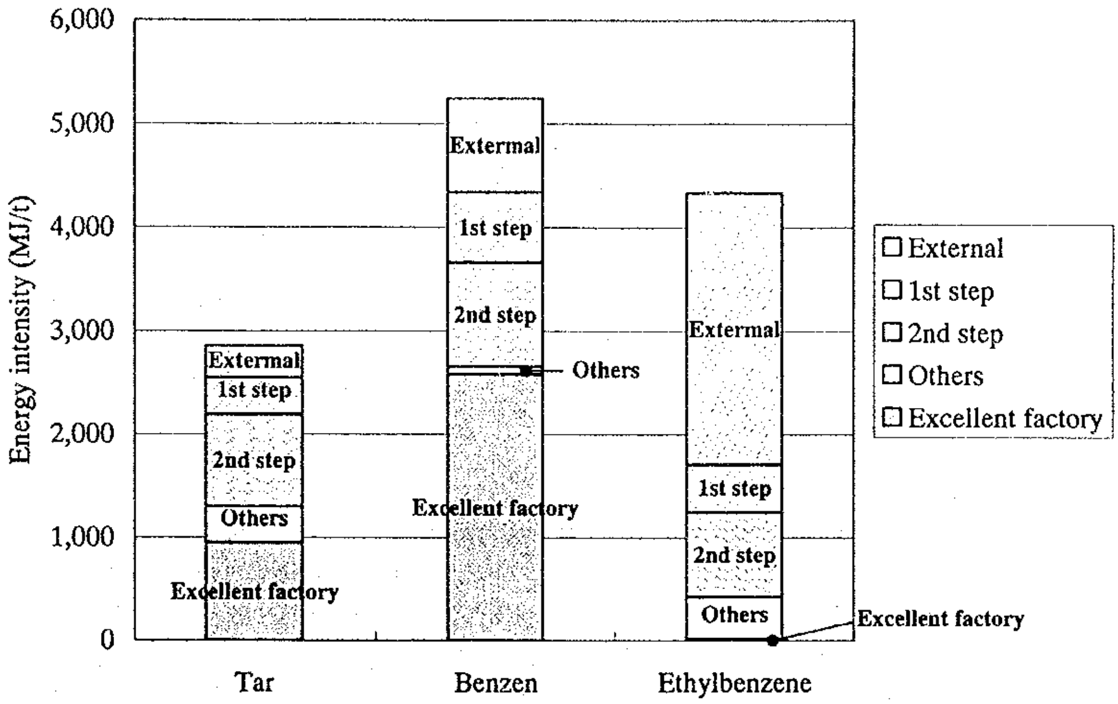
Step 2 Energy Conservation Measures

Recommended measures include improving the thermal insulation of the tar heating furnace and increasing the number of heat exchangers. It is estimated that these measures can achieve a fuel saving of 23 %.

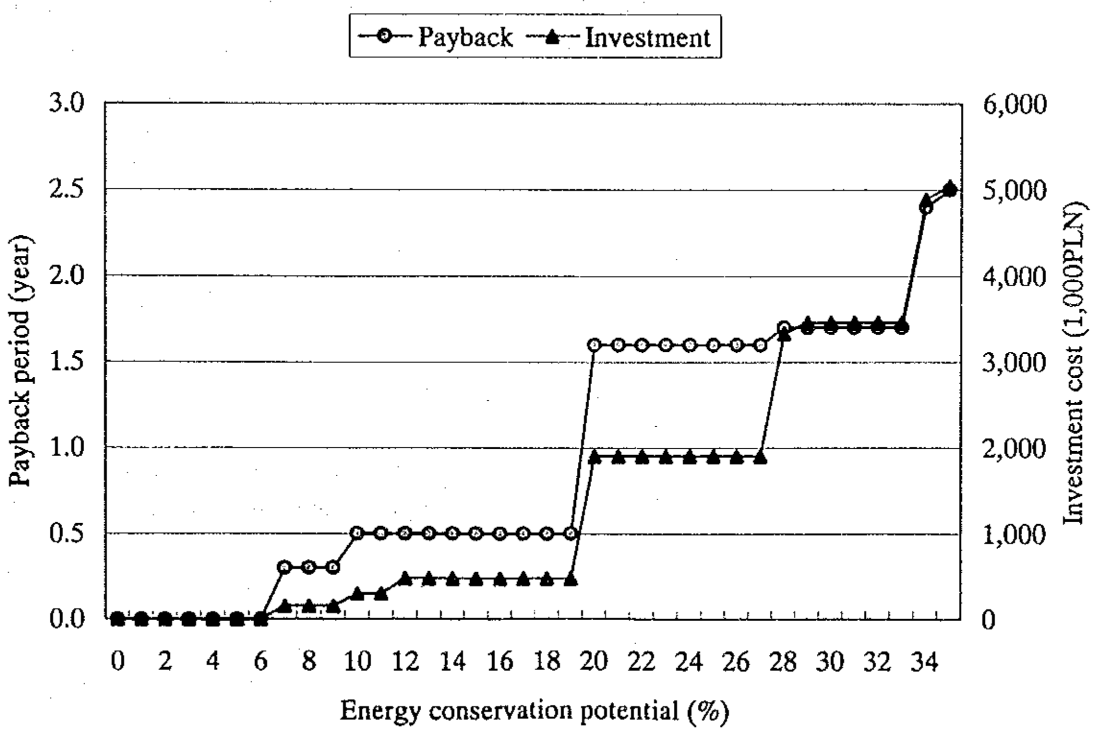
Step 3 Energy Conservation Measures

This type of chemical plant mainly encompasses petrochemical complexes, mainly oil refineries, and in such plants, as in the case of this one, in which the raw material is obtained from outside, investment in improvement of processes cannot be expected to produce significant results.

Brachownia Energy Conservation Potential



Brachownia Energy Conservation Potential



(2) Factory of POCH

POCH, the only industrial reagent factory in Poland, manufactures 800 types of products from reagents in units of gram to testing fertilizers, annual production of which is 200 t.

a. Energy management status

POCH manufactures many types of products in batch processing using the same reaction facility, resulting in a large amount of energy loss. Hence, enhancement of environmental protection measures is required.
The pressure of 42 kg/cm^2 steam generated from the steam boiler is reduced to 5 kg/cm^2 by a pressure reducing valve for use with the heat source for processing and space heating, thus making energy loss large. Energy required for space heating (air conditioning) accounts for 50 % of the total energy consumed.

b. Energy conservation potential

The energy intensity in 1996 excluding energy for space heating was 63,000 MJ/t. Through steps 1 and 2 only, a 46 % energy conservation potential is made available. It is estimated that an 18 % energy saving can be achieved by enhancement of energy management such as improvement of boiler air ratio and investment for facility improvement based on the payback period within 3 years.

Step 1 Energy Conservation Measures

Recommended measures include lowering the air ratios of the boilers and the capacity of the power-receiving transformers. This is estimated to achieve savings of 16.5 % in fuel and 1 % in electricity consumption.

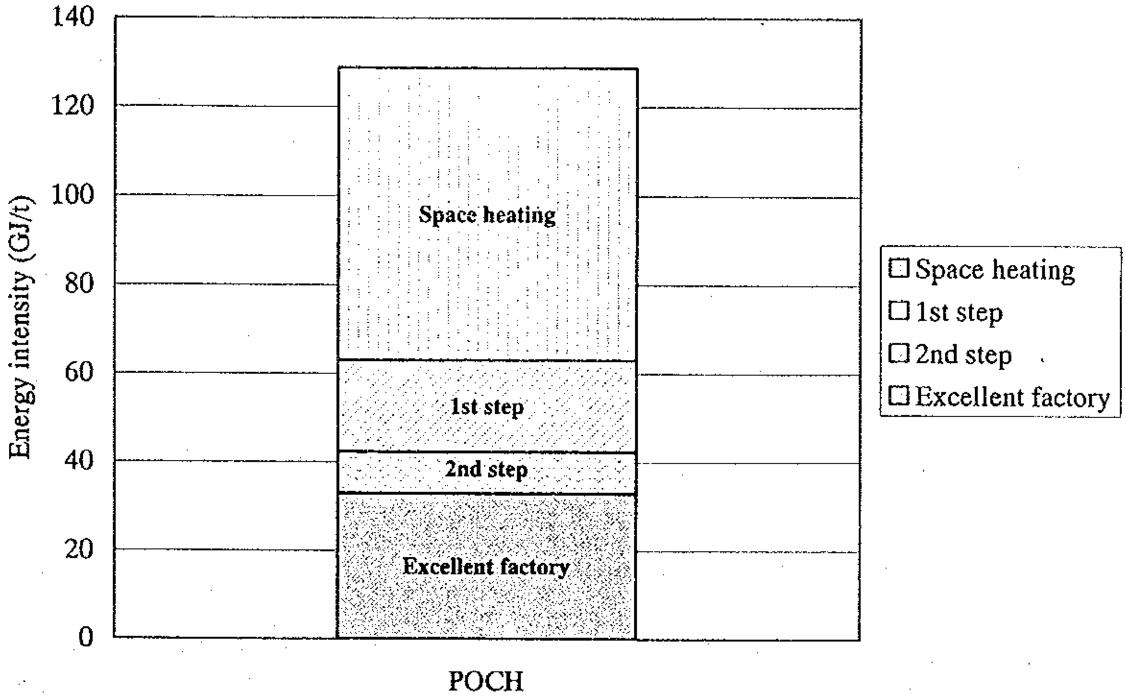
Step 2 Energy Conservation Measures

Addition of steam trap devices and improvement of the heat insulation of steam valves are recommended. This is expected to achieve a saving of 6 % in fuel consumption.

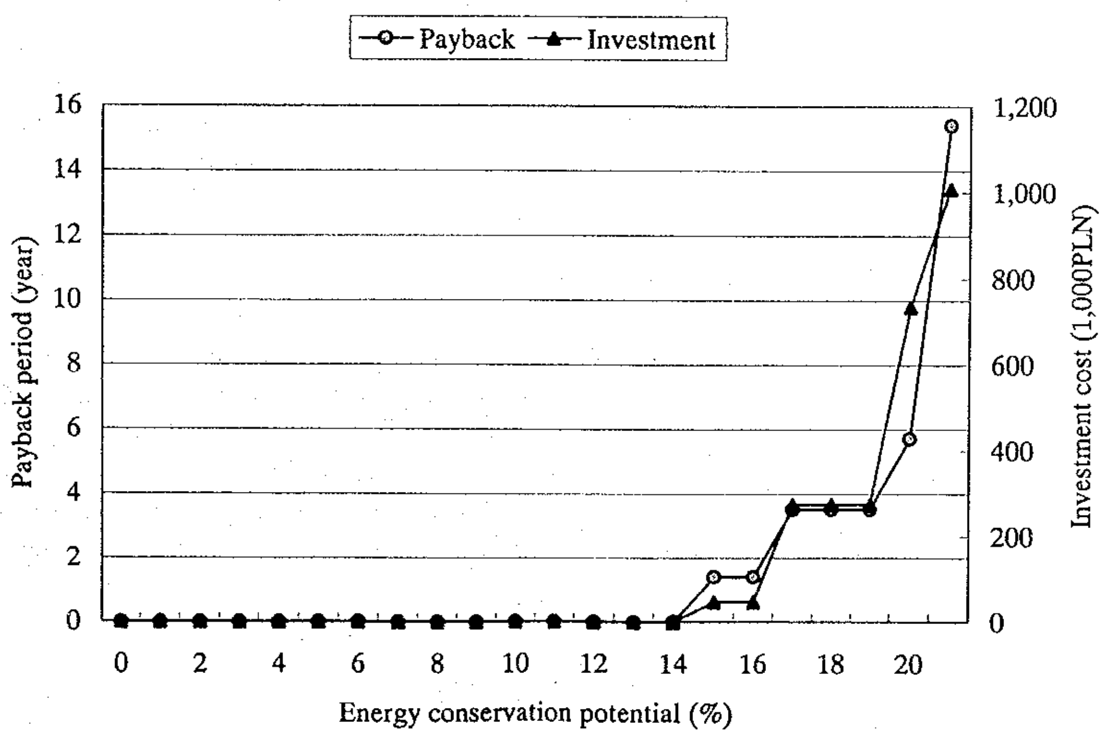
Step 3 Energy Conservation Measures

This factory is engaged in small-lot, wide variety production, and therefore few significant results can be expected from improvements in processes.

POCH Energy Conservation Potential



POCH Energy Conservation Potential



(3) Factory of Boruta

The Boruta's domestic market share in chemical dyes is 40 % and the factory is located in Ludzi, a town of fibers. Before 1989, this factory manufactured explosive intermediate materials for dyes. Factory buildings are located on the wide site (2 km square), thus causing large amounts of distribution loss of steam and compressed air. The production volume is significantly low for the equipment capacity. Field survey was conducted at the reactive dye factory only. Through restructuring, a large number of employees were cut down and the power plant and sewage processing facility in the utility division were separated as different companies.

a. Energy management status

The spray dryer used for producing powder dyes consumes a large volume of steam. Measuring equipment should be increased and upgraded.
To reduce energy for space heating in the factory building, windows glass is replaced with laminate resin panels.

b. Energy conservation potential

The energy intensity of the reactive dyes in 1997 was 88 GJ/t, indicating that the factory has a 46 % energy conservation potential if 48 GJ/t of the excellent factory is used as the benchmark. Through enhancement of energy management and investment for facility improvement based on the payback period within 3 years, a 13 % energy savings is expected to be achieved.

Step 1 Energy Conservation Measures

It is recommended that the number of cycles of the filtration process within the reaction process be reduced by one, and that lighting be turned off during daylight hours. This is estimated to allow a 5 % saving in electricity consumption.

Step 2 Energy Conservation Measures

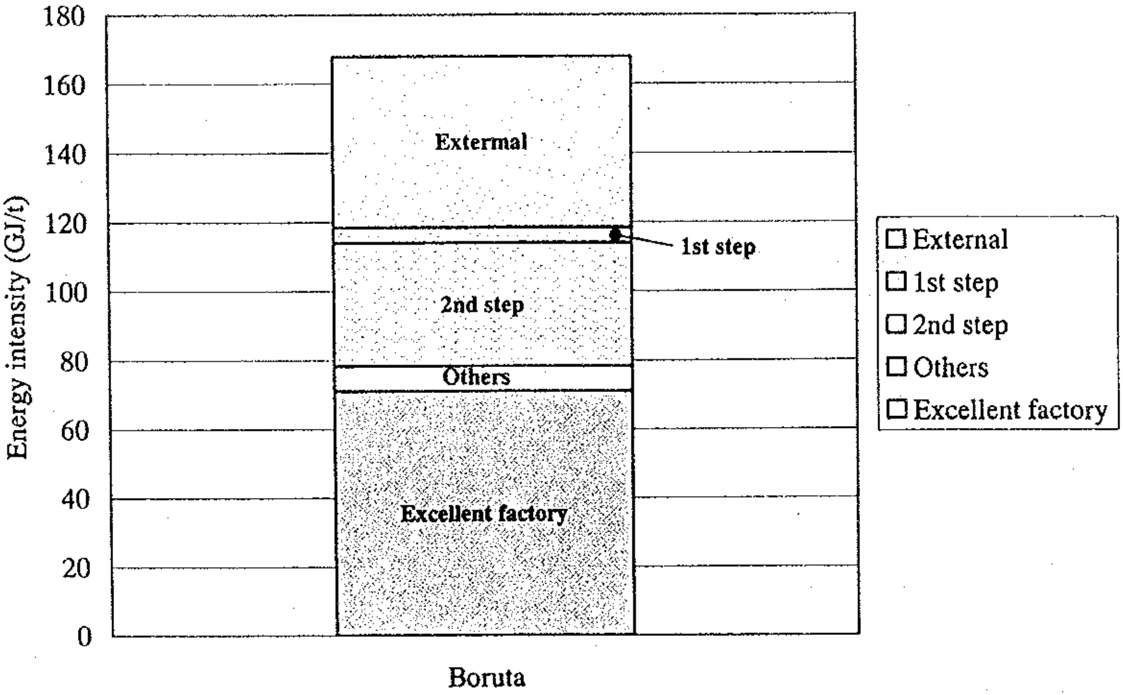
Recommended measures include expansion of sales of liquid products to large industrial users, improvements to the spray dryer air heaters, the recovery and recycling of condensate from the spray dryer air heaters, decentralized location of air compressors, integration of steam pipes, automation of the raw material supply process, and improvements in the method of supply of ice. It is estimated that these measures can lead to savings of 11 % in steam and 57 % in electricity consumption.

Step 3 Energy Conservation Measures

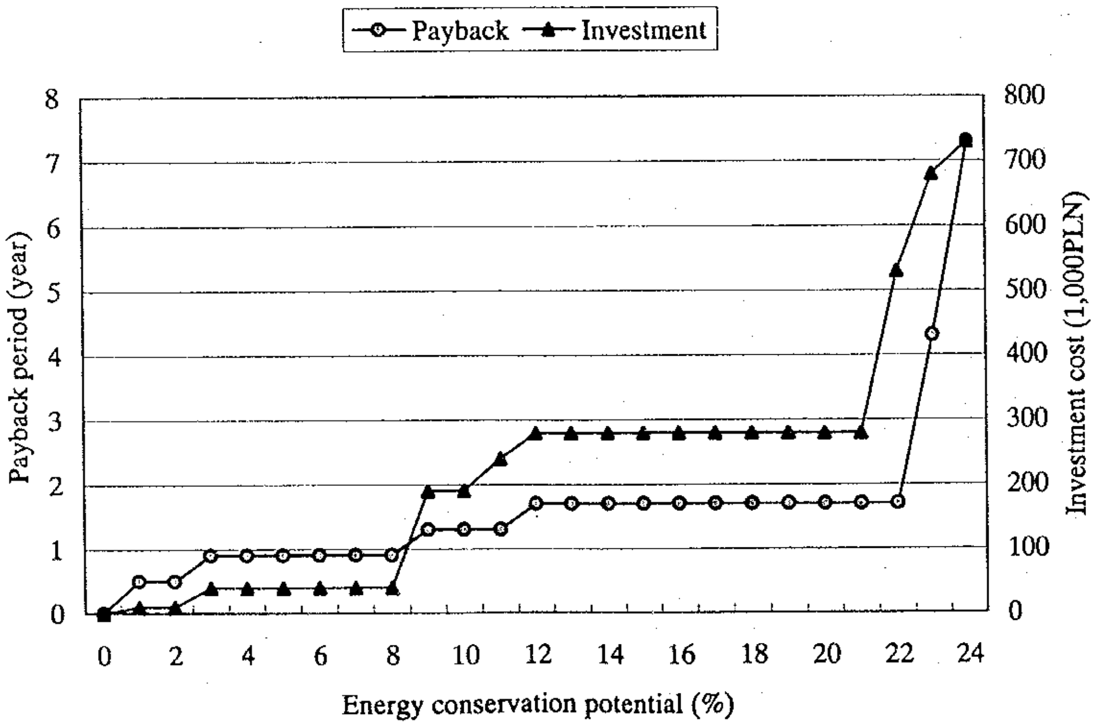
As Borut's current restructuring policy involves downsizing, no Step 3 recommendations have been made.

In view of the present trend for dyestuff factories in the advanced industrialized nations to downsize and transfer operations to plants in China and India, it is estimated that in the event of Borut replacing its present superannuated equipment, it will be able to manufacture higher-quality products by the establishment of a system for the production, not only of its current mainline - powdered dyestuffs - but also of granular dyestuffs, coloring agents, and surface-active agents (surfactants). The introduction of state-of-the-art equipment would also enable the company to achieve the desired levels of energy conservation.

Boruta Energy Conservation Potential



Boruta Energy Conservation Potential



8.1.3 Machine Manufacturing Industry

The URSUS Warsaw factory, a typical tractor factory in Poland, and the STAR Starachwice factory, a medium-size truck factory, were surveyed. For both companies, the production volume is significantly low for the factory's production capacity due to the slump in export and competition with imported products. The assembly line employs 1-shift (8-hour) operation. Thus, restructuring through introduction of an external capital is currently under planning.

(1) Warsaw factory of URSUS

The factory of URSUS headquarters is a typical tractor factory in Poland, which has an integrated production line for the processes from parts machining to assembly. During restructuring, the tool plant that introduced HOPP (Human Oriented Program for Production) under the guidance of the JICA experts is active, with order reception from the outside amounting to 30 %.

a. Energy management status

Some measures proposed in the study in 1997 have been implemented: e.x. stopping the heating furnace for cutting the forging material, introduction of a small-sized air compressor, and centralized production for the engine fabrication factory.
However, only a partial space of the large plant building is in use, thus producing large losses of energy used for space heating, lighting, compressed air , etc. The result of measuring the compressed air leak volume in the forging factory revealed that there was a leakage of air equivalent to a 2000 kW compressor.

b. Energy conservation potential

The energy intensity in 1997 excluding energy for space heating was 78.5 GJ/set. This indicates that the factory has a 43 % energy conservation potential if 45 GJ/set of the excellent factory is used as the benchmark. Enhancement of energy management and investment for facility improvement based on the payback period within 3 years are estimated to achieve a 19 % energy saving.

Step 1 Energy Conservation Measures

It is recommended that the air ratios of the boilers be improved, and that the rate of leakage of compressed air be reduced. It is estimated that these measures will result in savings of 2 % in fuel and 4 % in electricity consumption.

Step 2 Energy Conservation Measures

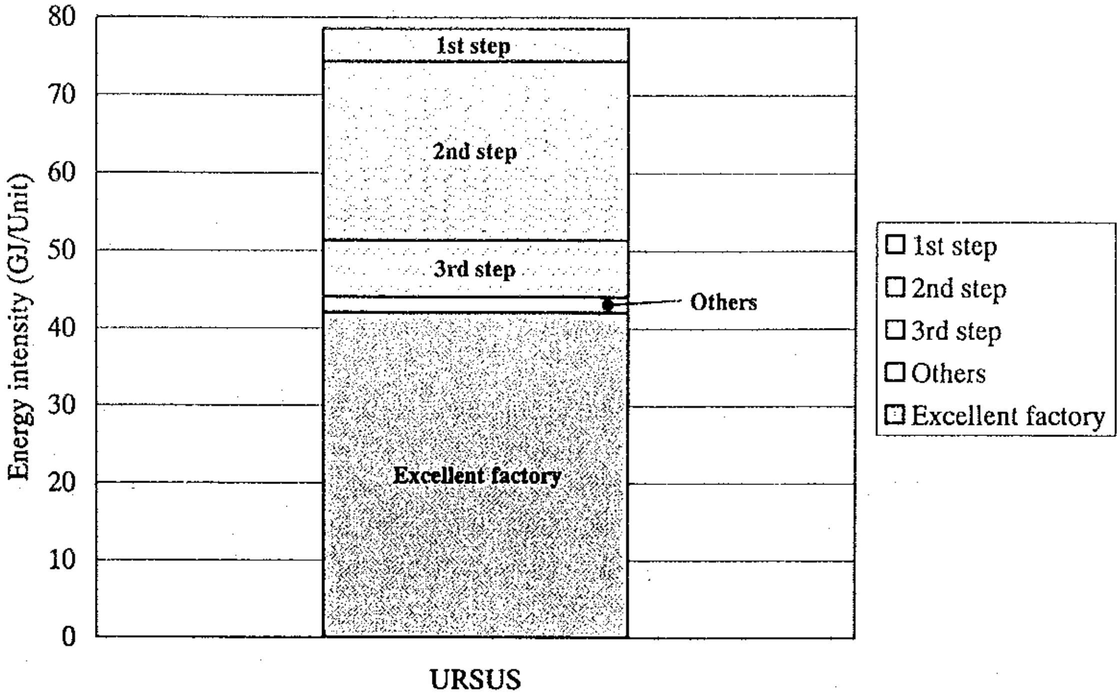
Measures recommended include the implementation of integrated production for the assembly shop, the installation of small air compressors for use under low load, the adoption of the method of stopping operation of processing machines after one cycle, and the use of rotational speed control for pumps and fan motors. These measures are estimated to achieve savings of 12 % in fuel and 23 % in electricity.

Step 3 Energy Conservation Measures

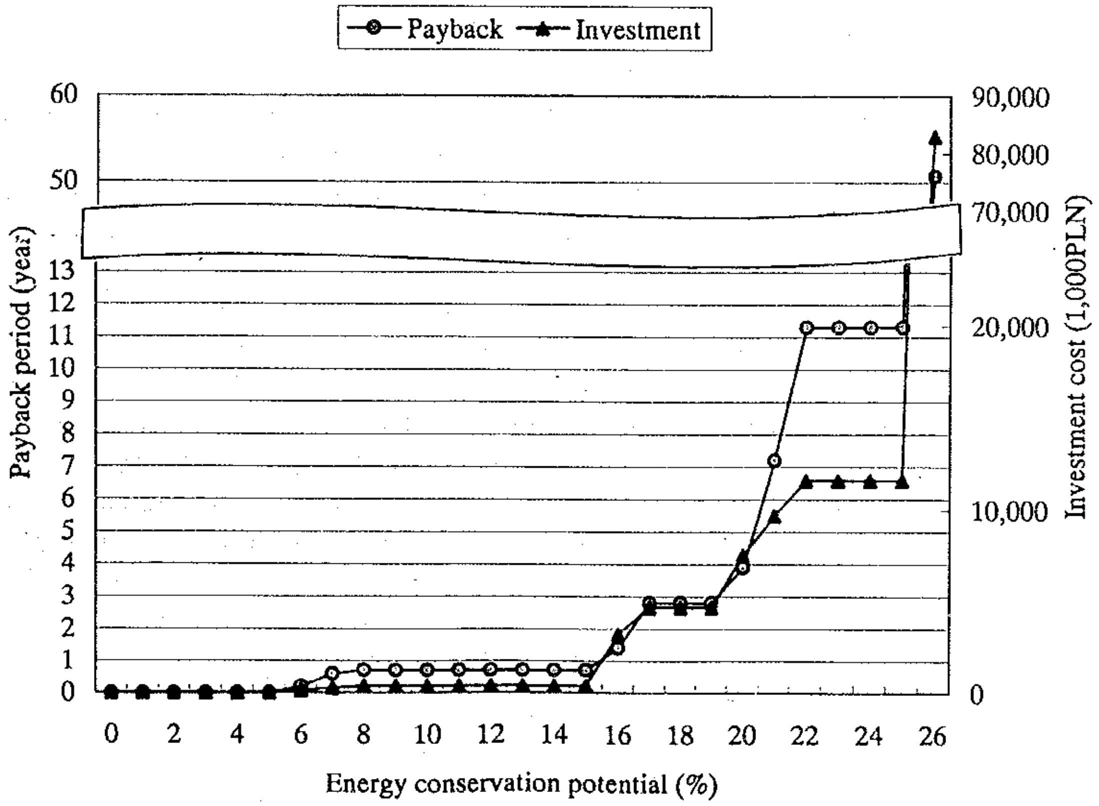
Measures recommended include the installation of a hot air cupola at the casting mill, rationalization of processing lines at the processing and assembly plant, and increasing of the yields of the engine component production lines. It is estimated that these measures will lead to savings of 4 % in fuel and 8 % in electricity. As the purchase of a hot air cupola and new processing equipment would involve a large investment, it is recommended that these measures be decided on the basis of the company's long-term management strategy.

Energy conservation through integration of processes, and revitalization of the management staff and other employees through the HOPP system are recommended as necessary measures for the factory as a whole.

URSUS Energy Conservation Potential



URSUS Energy Conservation Potential



(2) Starachwice factory of STAR

STAR is manufacturing medium-size trucks and military vehicles. The production volume is declining because import of large trucks is increasing. Integration of plants is being planned in line with the future capital introduction from a German motor company.

a. Energy management status

Only a partial space of a large factory building is used, causing significant losses of energy used for space heating, lighting, and compressed air. Energy consumption for space heating accounts for 40 % of the total energy amount used in the factory.

b. Energy conservation potential

The energy intensity in 1996 excluding energy used for space heating was 119 GJ/set. This indicates that this factory has a 75 % energy conservation potential if 29 GJ/set of the excellent factory is used as the benchmark. Through enhancement of energy management and investment for facility improvement based on the payback period within 3 years, a 36 % energy saving will be possible.

Step 1 Energy Conservation Measures

Recommended measures include the enhancement of supervision on a separate basis for each division, which is estimated to achieve savings of 5 % in fuel and 5 % in electric power consumption.

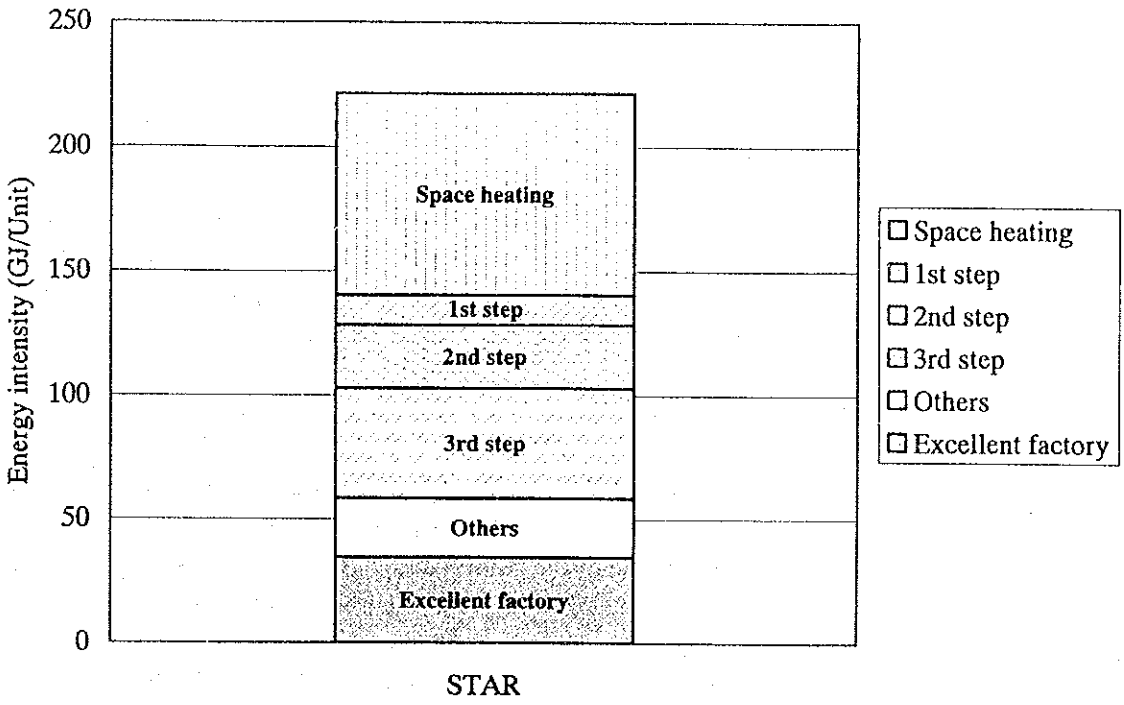
Step 2 Energy Conservation Measures

Recommended measures include improvement of control of the paint drying ovens, the introduction of integrated or centralized production processes, improved control of the operation of air compressor, and changes in the compressed air pressure. By these means, savings of 14 % in fuel and 3 % in electricity consumption is estimated to be achieved.

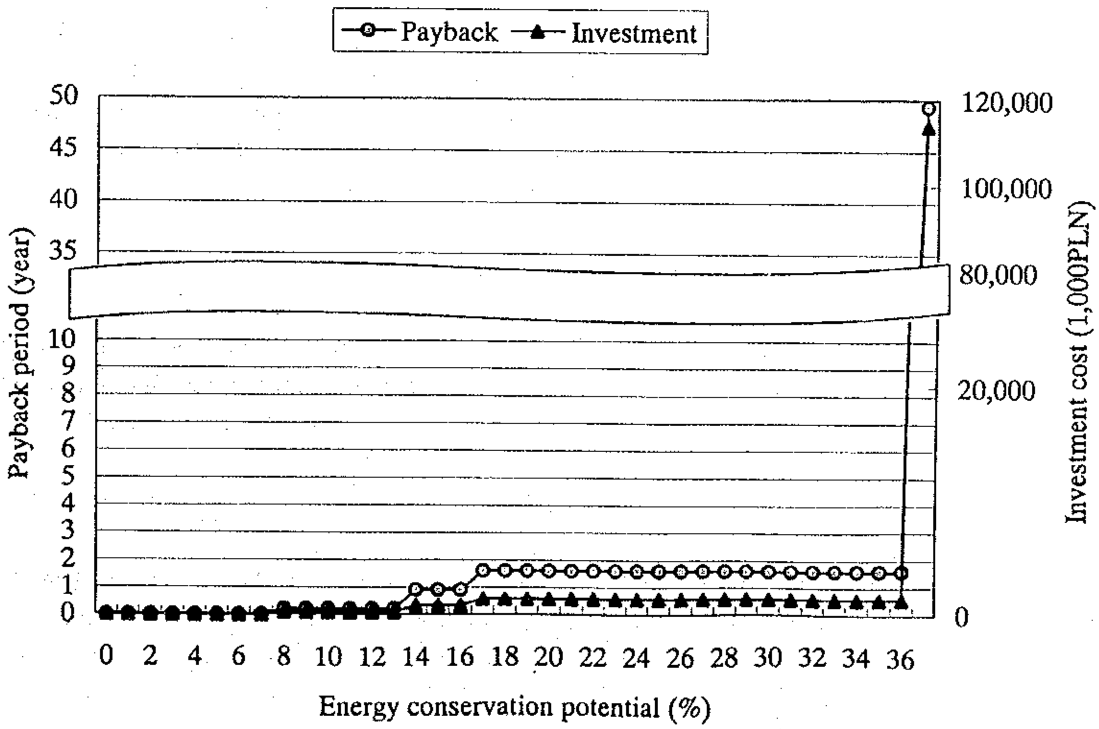
Step 3 Energy Conservation Measures

Modernization of the processing lines is recommended. This is estimated to achieve savings of 7 % in fuel and 44 % in electricity consumption. As a considerable investment will be needed to introduce new-model processing equipment, it is recommended that this be implemented on the basis of a long-term management strategy.

STAR Energy Conservation Potential



STAR Energy Conservation Potential



8.1.4 Non-metallic Materials Industry (glass and silica block manufacturing)

The survey covered the factories of Wolomin Glass having a 7 % market share for bottle glass in Poland and Silikaty having a 2 to 3 % market share for silica blocks to be used for residence walls.

(1) Factory of Wolomin headquarters

Wlomin manufactures bottles for drinks such as vodka, heat-resistant glass tableware, thermos bottles, and laboratory glassware. While bottles for drinks are in competition with those made by a foreign joint corporation, this factory has special technologies for manufacturing heat-resistant glass and thermos bottles. To shift to a private company, it schedules bidding by foreign investors in November, 1998.

a. Energy management status

The measures recommended as a result of the 1997 survey, i.e., control of combustion in the melting furnace and the use of heat exchangers with the boilers, have been implemented. As the load of the equipment is low, energy loss due to heat radiation is significantly large. In addition, the production yield of 80 % is well below the average for the company' competitors, which stands at 95 %. No energy management targets have been set at either the factory level or the individual production line level.

b. Energy conservation potential

The energy intensity of the bottle glass facility in 1997 was 26.7 GJ/t. This indicates that the factory has a 58 % energy conservation potential if 11.2 GJ/t of the excellent company is used as the benchmark. Through enhancement of energy management and investment for facility improvement based on the payback period within 3 years, a 24 % energy saving is estimated to be accomplished.

Step 1 Energy Conservation Measures

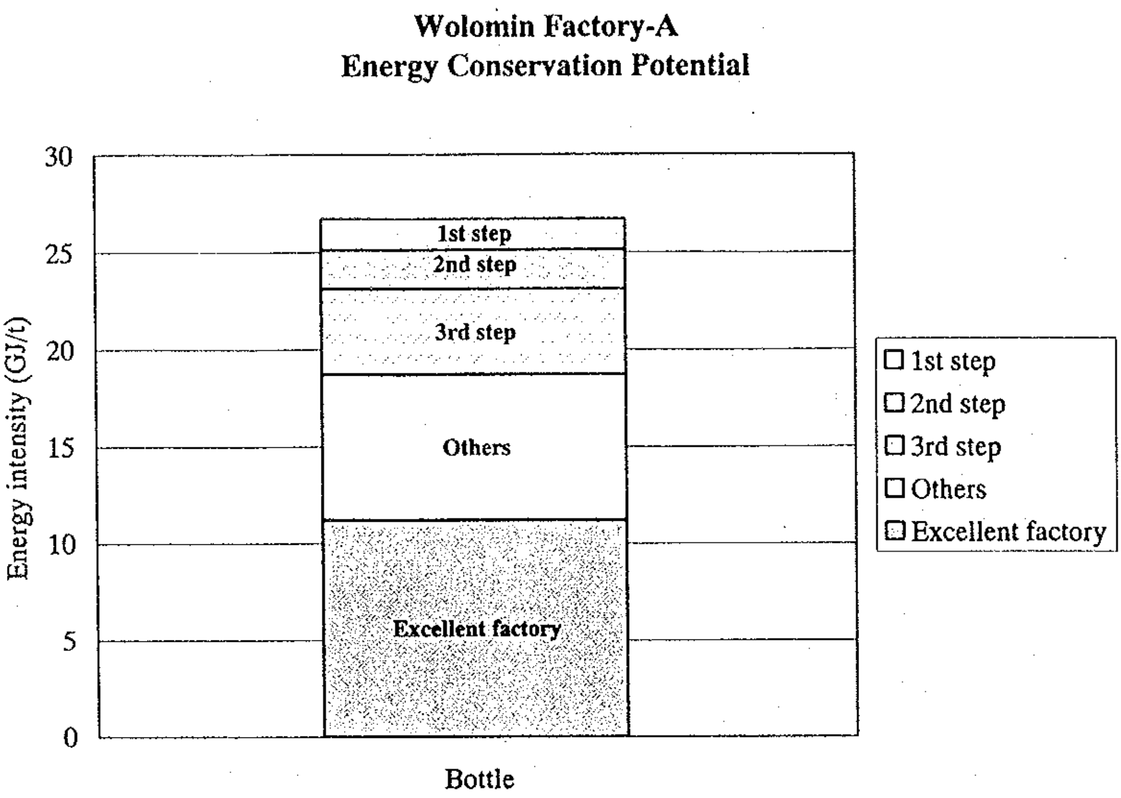
It is recommended that the air ratio of the melting furnace be improved, and that modifications be made to the pressure levels of the air compressors. These measures are estimated to achieve savings of 5 % in fuel and 8 % in electricity.

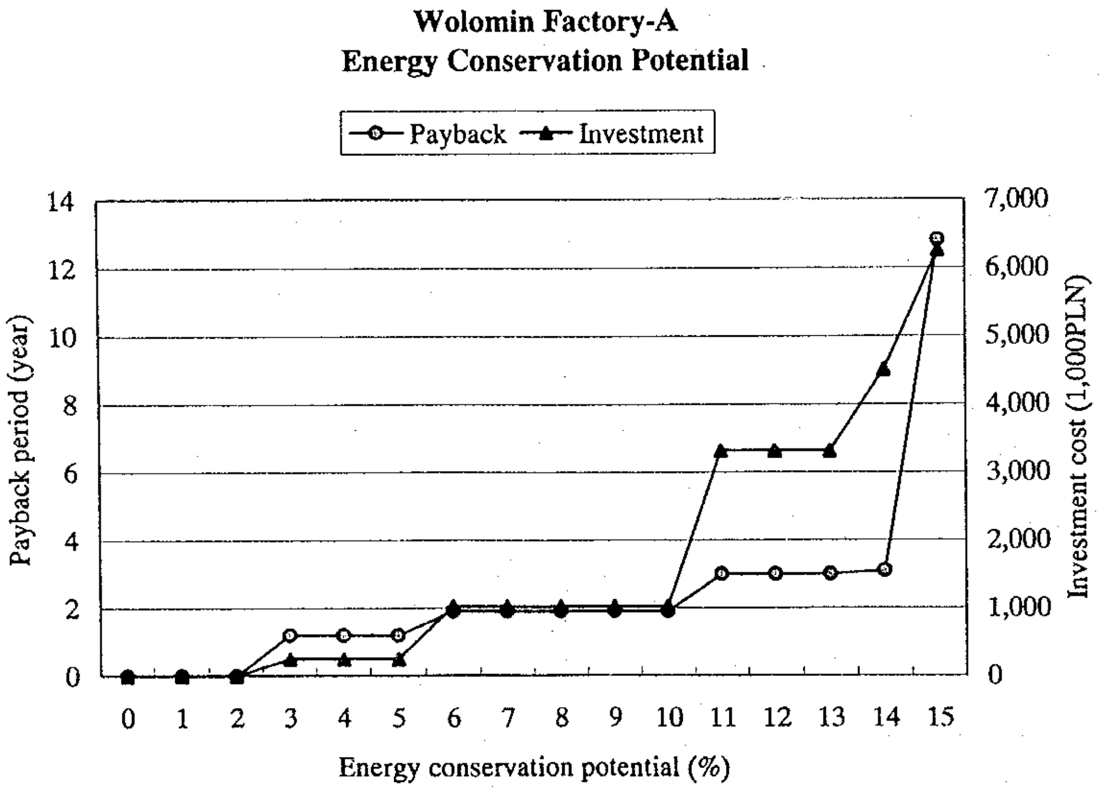
Step 2 Energy Conservation Measures

Recommendations include improvement of the heat insulation of the melting furnace, modification of the regenerator, and the use of rotational speed control for fan motors. It is estimated that these measures can lead to savings of 9 % in fuel and 2 % in electricity.

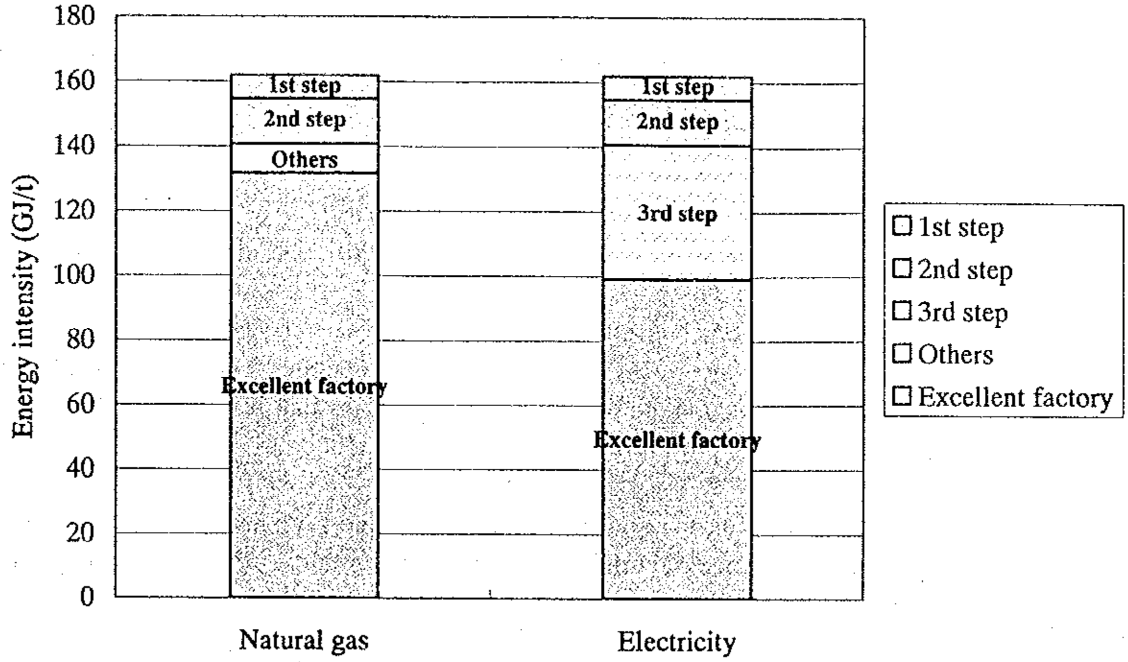
Step 3 Energy Conservation Measures

The capacity of the bottle glass melting furnace should be reduced in line with production volume, the melting furnace for heat-resistant glass should be converted into an electric meltimg furnace, and production yields should be raised. If these recommended measures are implemented, it is estimated that electricity consumption can increase by 80 %, but a saving of 46 % in fuel consumption can be achieved, thus leading to an overall energy saving of 20 %.

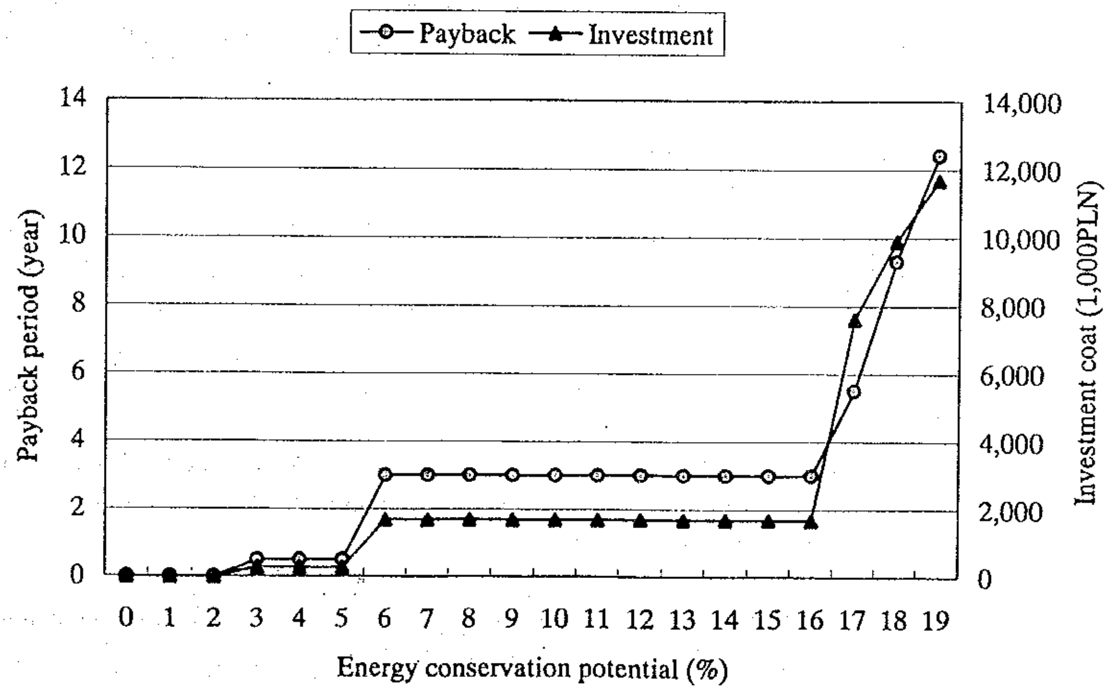

Wolomin Factory-A
Energy Conservation Potential
30
25
20
15
10
5
0
Energy intensity (GJ/t)
1st step
2nd step
3rd step
Others
Excellent factory
Bottle
1st step
2nd step
3rd step
Others
Excellent factory


Wolomin Factory-A
Energy Conservation Potential
Payback
Investment
14
12
10
8
6
4
2
0
Payback period (year)
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
Investment cost (1,000PLN)
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
Energy conservation potential (%)

Wolomin Factory-B
Energy Conservation Potential



Wolomin Factory-B
Energy Conservation Potential



(2) Radom factory of Silikaty

Silikaty manufactures silica blocks by hardening and curing through autoclaving using limestone and silica. In Poland, there are 36 silica block manufacturing companies having the equivalent production capacity. The 1998 Holland Environmental Protection Project is applied to this factory only, while also the proposal for the factory by the JACA study team has been adopted to be implemented. This factory is scheduled to be designated as an energy conservation model factory.

a. Energy management status

The top management show positive attitudes for new product development and energy conservation.
There is an insufficient number of steam flow meters, and the autoclave control devices are also not sufficient. The boiler is operated manually. Insufficiencies were also observed in the mixing of raw materials and the control of water-content levels.

The company plans to replace its coal-fired boilers with natural gas-fired boilers , to purchase a raw material mixing machine, and to improve the raw material treatment process.

b. Energy conservation potential

The energy intensity in 1996 was 1,680 MJ/t. This indicates that the factory has a 57 % energy conservation if 720 MJ/t of the excellent factory is used as the benchmark. A 36 % energy saving is estimated to be achieved by enhancement of energy management and investment for facility improvement based on the payback period within 3 years.

Step 1 Energy Conservation Measures

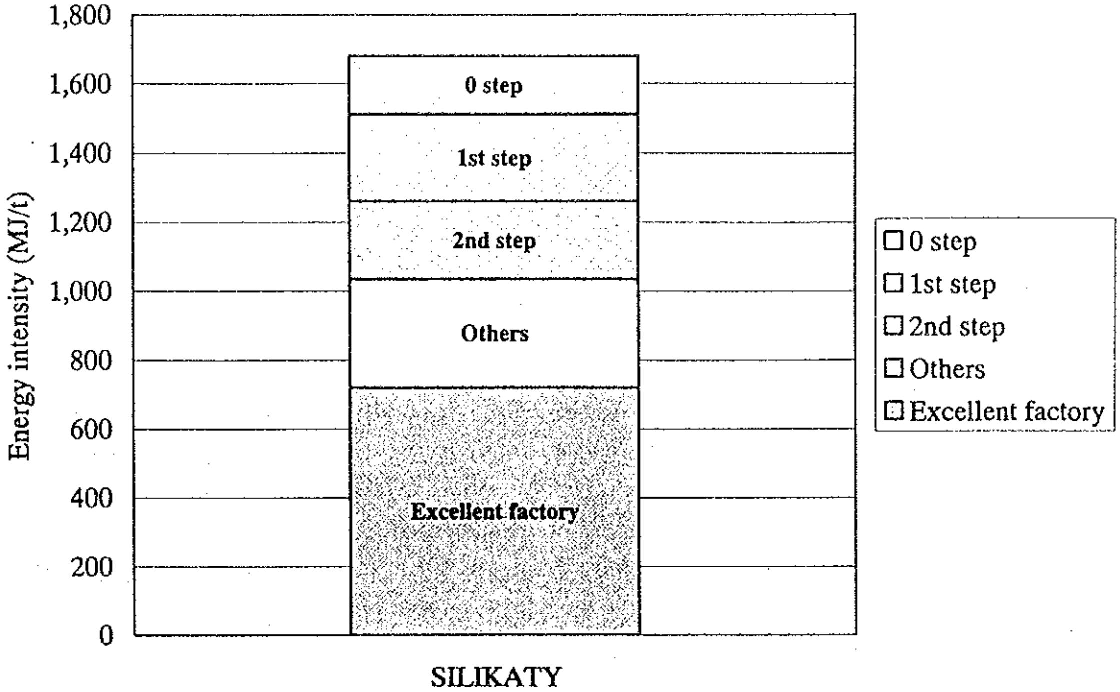
It is recommended that improvements be made in the operational pattern of the autoclaves and the air ratios of the boilers. This is estimated to achieve a saving of 16 % in fuel.

Step 2 Energy Conservation Measures

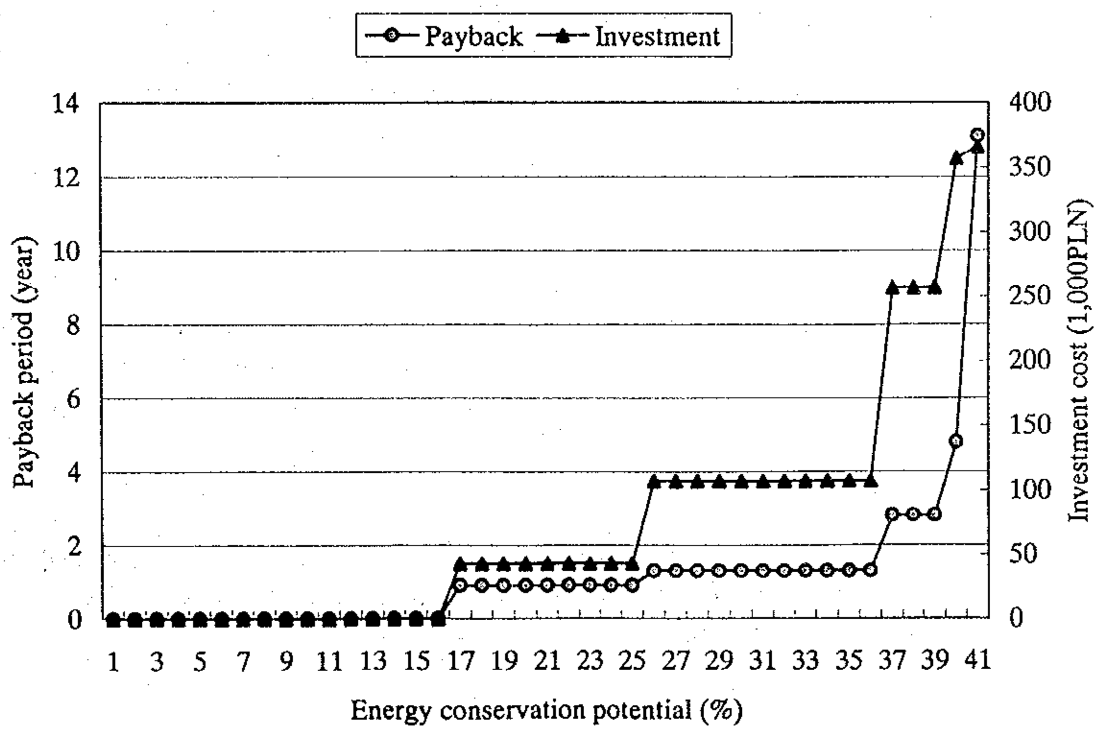
The recovery and recycling of steam used in the autoclaves, and the improvement of the heat insulation of steam valves are recommended. It is estimated that this can achieve a saving of 15 % in fuel.

In addition to Steps 1 & 2 of the energy conservation measures recommended by JICA above, Silikaty has applied to KAPE for permission to carry out a project involving improvement of the processing of raw materials and the installation of natural gas-fired boilers. To this end, the company is receiving technical knowhow and financial assistance from the Netherlands.

SILIKATY Energy Conservation Potential



SILIKATY Energy Conservation Potential



8.1.5 Food Processing Industry

The survey covered two factories of Obrzanska and MLECZ manufacturing dairy products, two factories of Koscian Meat and LUBMEAT engaged in meat processing, and OLVIT manufacturing edible oil.

(1) Factory of OLVIT headquarters

OLVIT manufactures refined oil and margarine from raw oils such as soybean oil and rapeseed oil. Since last year, an edible oil company in Denmark has participated in business administration. Presently, restructuring is being planned.

a. Energy management status

Olvit's factory manager is aware of the cost-reduction benefits achievable through energy conservation. The energy intensity is being utilized in the management of production costs, but there are no actual measurement figures due to a lack of sufficient numbers of measurement instruments.
The factory receives a supply of steam from an adjacent heat supply center. Its hydrogen generator is of the electrolytic type, and consumes 45 % of the factory's total electric power requirements.

b. Energy conservation potential

The energy intensity in 1996 was 5,150 MJ/t, which indicates that this factory has a 48 % energy conservation potential if 2,703 MJ/t of the excellent factory is used as the benchmark. Through enhancement of energy management and investment for facility improvement based on the payback period within 3 years, a 15 % energy saving will be made possible.

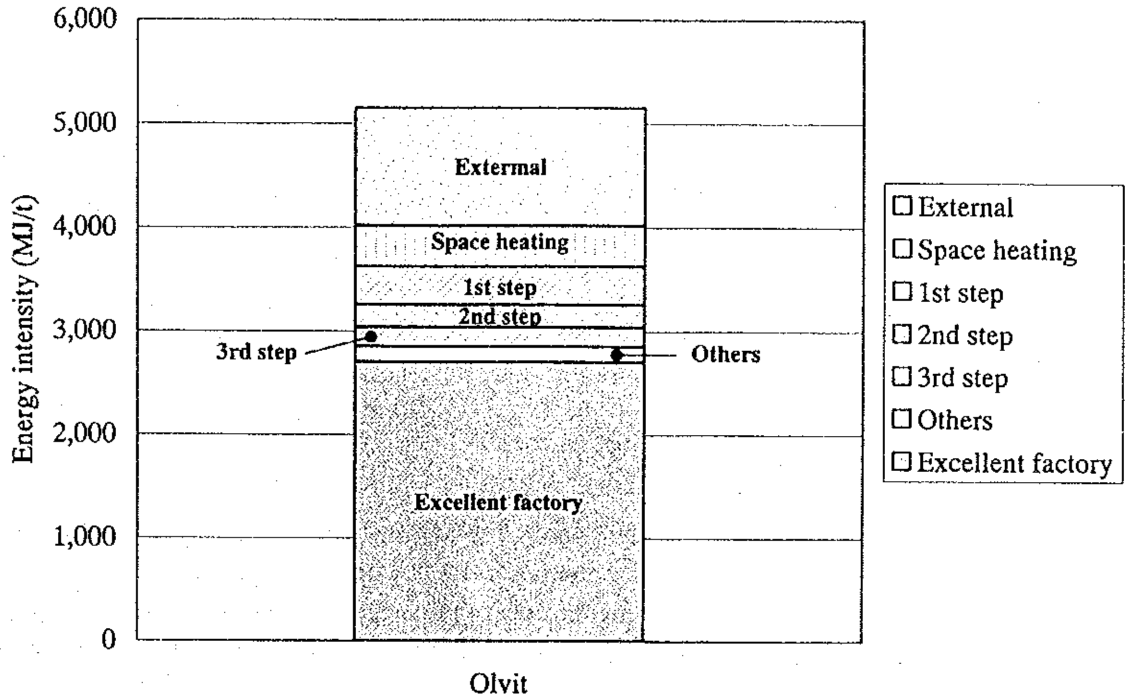
Step 1 Energy Conservation Measures

It is recommended that steps be taken to reduce heat emission loss from the deodorizing column, and that adjustments be made to the degree of vacuum within the deodorizing column and the steam pressure in the ejector. The implementation of these measures is estimated to achieve a saving in fuel of 11 %.

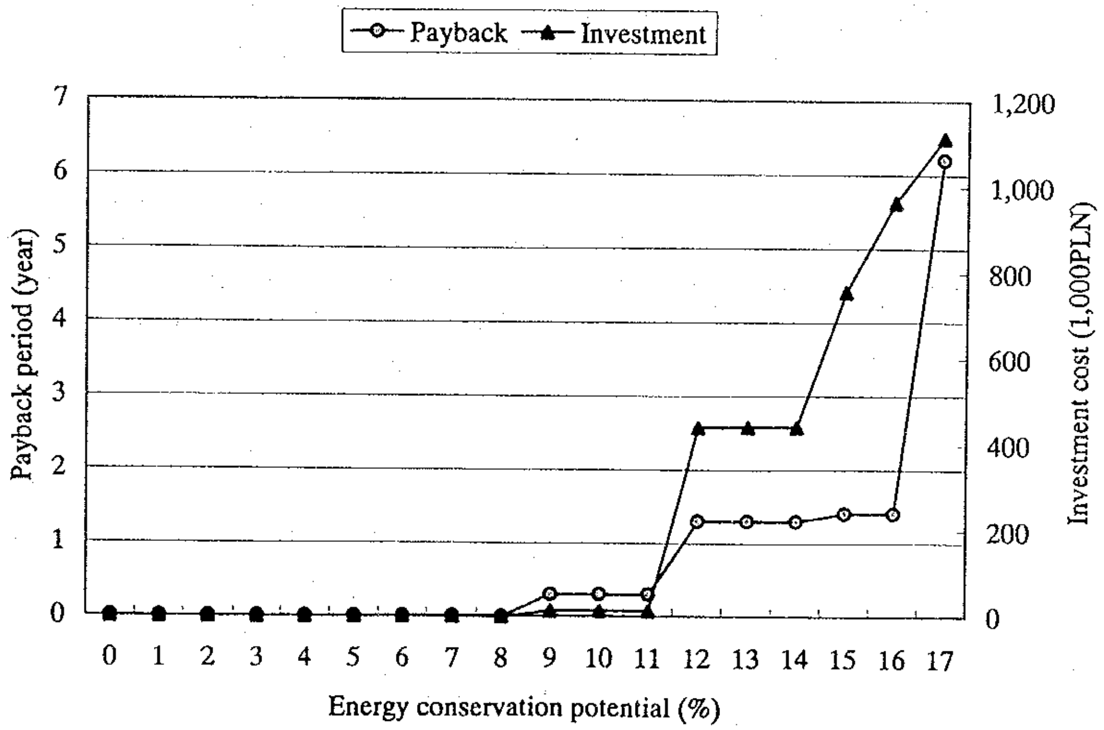
Step 2 Energy Conservation Measures

Improvement of the method of heating used in the deodorizing column, and that of the heat insulation of steam valves are recommended. This is expected to achieve a saving of 6 % in fuel.

Olvit Energy Conservation Potential



Olvit Energy Conservation Potential



(2) Factory of Koscian Meat headquarters

Koscian Meat manufactures carcasses, ham, and sausage through butchery of pigs. Actual production volume is only 30 % of production capacity.

a. Energy management status

As the energy cost ratio of this plant is low, the company does not place high priority on energy management, and there is no grasp of the amounts of energy consumed by each piece of equipment, or of the energy intensity among the management staff.

Since the refrigerated air within the plant is allowed to escape into the atmosphere, the refrigeration facilities within the plant buildings and warehouses consume a large amount of energy.

b. Energy conservation potential

The energy intensity in 1996 was 8,407 MJ/t, which indicates that this factroy has a 50 % energy conservation potential if 4,238 MJ/t of the excellent factory is used as the benchmark. Enhancement of energy management and investment in equipment improvement based on the payback period within 3 years are estimated to achieve a 7 % energy saving.

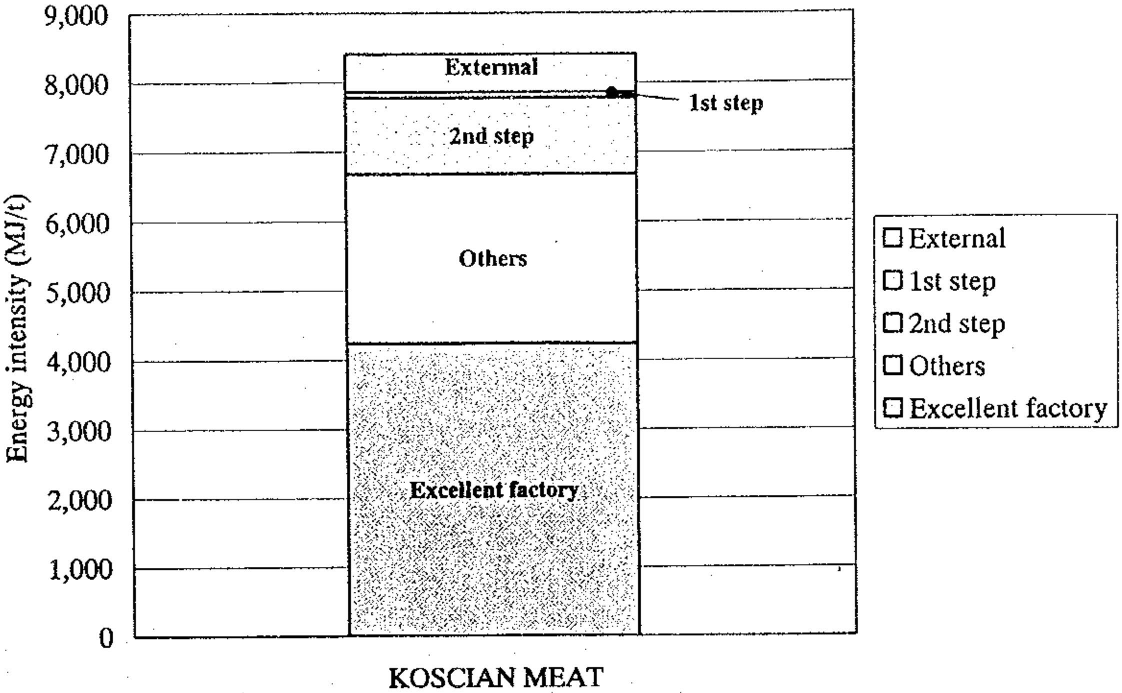
Step 1 Energy Conservation Measures

The installation of curtains at the plant's entrances and exits is recommended. This is expected to allow a saving of 1 % in both fuel and electricity.

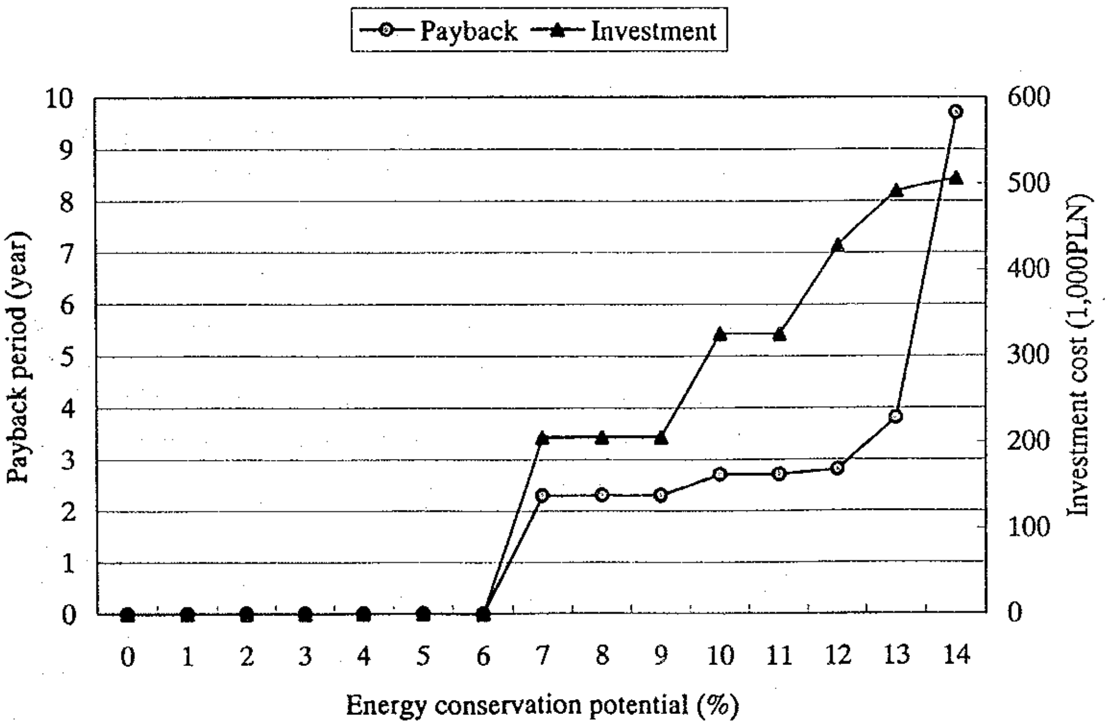
Step 2 Energy Conservation Measures

Recommended measures include raising the recovery rate of condensate from the heating process, improving the heat insulation of steam valves, reducing the refrigerating load by utilizing cold air from outside in winter, and changing the capacity of the compressors used in refrigeration. It is estimated that these measures can achieve savings of 15 % in fuel and 9 % in electricity.

KOSCIAN MEAT Energy Conservation Potential



KOSCIAN MEAT Energy Conservation Potential



(3) Factory of LUBMEAT headquarters

LUBMEAT manufactures carcasses, ham, and sausage through butchery of pigs and cattle. This factory is a large-scale one, which had been engaged in meat processing in a distribution system until 1989. Presently, its production volume is as small as approximately 30 % of the facility capacity, thus causing a large amount of energy loss. Also, products matching the tastes of consumers should be developed. Restructuring such as reduction of the site and downsizing of buildings is currently in progress.

a. Energy management status

Lubmeat has adopted a 50 % rate of energy conservation as one of its restructuring targets. Because of a shortage of measuring instruments and a lack of information available to energy supervisors, no management of energy intensity is being implemented at the moment.

The refrigerated air used in the plant is allowed to escape into the atmosphere.

b. Energy conservation potential

The energy intensity in 1996 was 14,379 MJ/t, which indicates that this factory has a 59 % energy conservation potential if 5,895 MJ/t of the excellent factory is used as the benchmark. Enhancement of energy management and investment for facility improvement based on the payback period within 3 years are estimated to allow a 13 % energy saving.

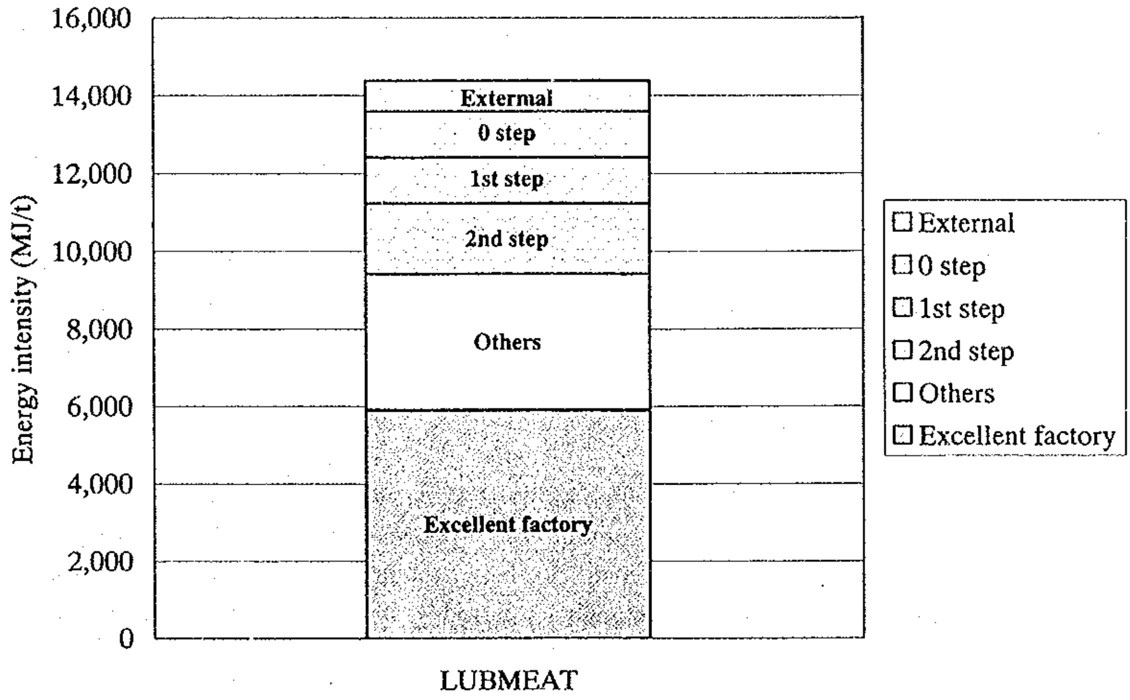
Step 1 Energy Conservation Measures

It is recommended to improve the boiler air ratio and the product yield. This can presumably lead to savings of 13 % in fuel and 2 % in electricity.

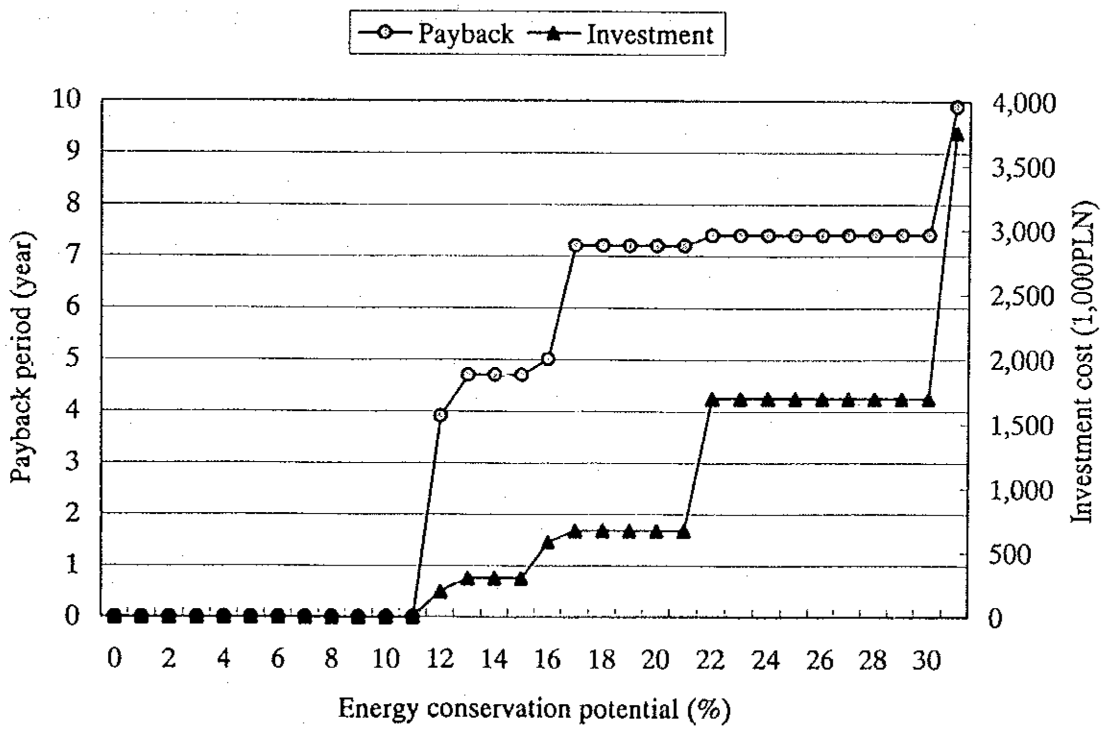
Step 2 Energy Conservation Measures

Recommended measures include raising the rate of recovery of condensate from the heating processes, reinforcement of the heat insulation of steam valves, reducing the refrigeration load by utilizing cold air from outside in winter, and installing curtains at the plant's exits and entrances. These measures are estimated to achieve savings of 15 % in fuel and 2 % in electricity.

LUBMEAT Energy Conservation Potential



LUBMEAT Energy Conservation Potential



(4) Factory of Obrzanska headquarters

Obrzanska has a factory manufacturing UHT milk and butter from raw milk. A union of 2000 dairy farmers forms the nucleus of business administration. This company is enthusiastic about new product development and new facility installation but production of butter has declined due to increasing margarine consumption.

a. Energy management status

The factory building is old but compact; therefore the energy distribution loss is small. A large amount of energy is consumed by cooling facilities in the factory and warehouse. The factory have no grasp of energy consumption for each process and equipment.

b. Energy conservation potential

The energy intensity in 1996 was 4,062 MJ/t, which indicates that this factory has a 15 % energy conservation potential if 3,448 MJ/t of the excellent factory is used as the benchmark. Enhancement of energy management and investment for facility improvement based on the payback period within 3 years are estimated to achieve a 9 % energy saving.

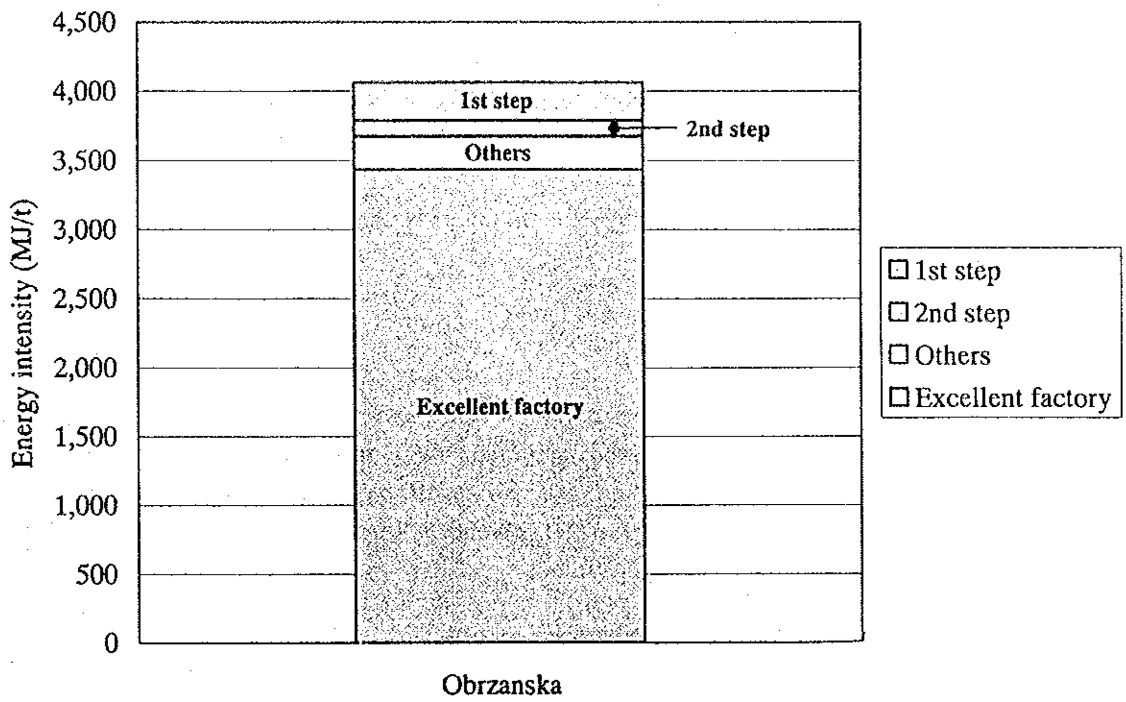
Step 1 Energy Conservation Measures

Recommendations include improvement of operation control of the milk sterilizer and increasing of the air ratios of the boilers. It is estimated that these measures can achieve a saving of 10 % in fuel.

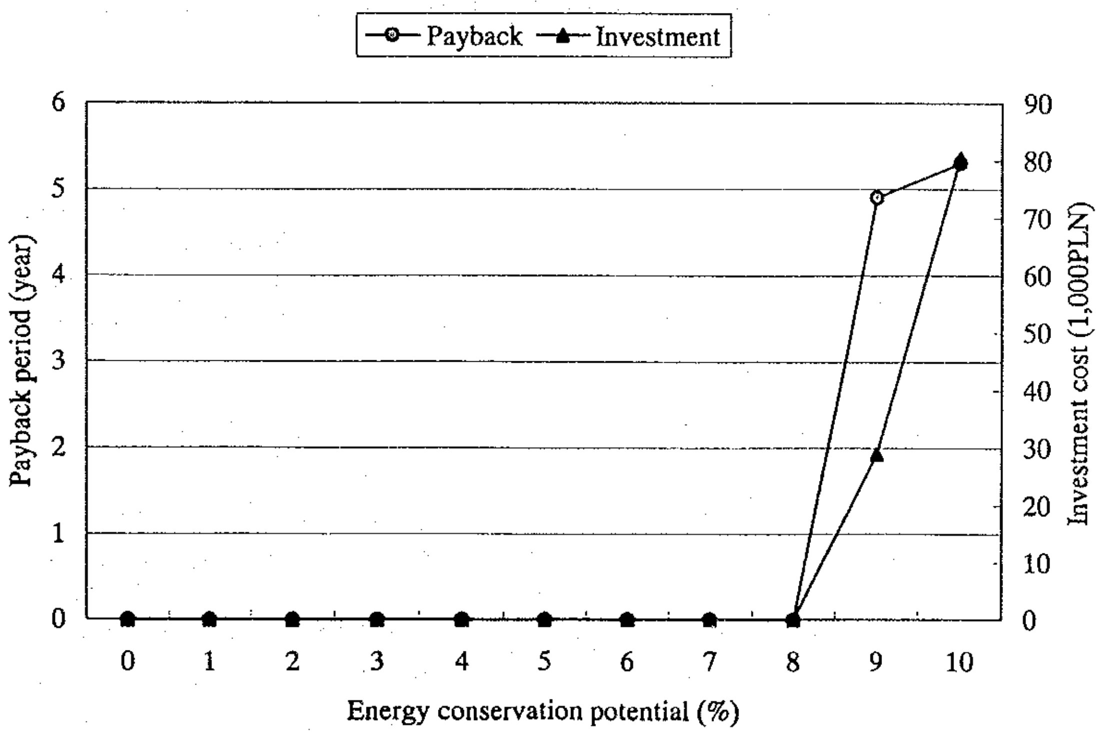
Step 2 Energy Conservation Measures

Improvement of operation control of refrigeration equipment, and improvement of heat insulation of steam valves are recommended. These measures are expected to achieve savings of 2 % in fuel and 3 % in electricity.

Obrzanska Energy Conservation Potential



Obrzanska Energy Conservation Potential



(5) Factory of MLECZ headquarters

The factory of the MLECZ headquarters manufactures HTST milk, powder milk, butter, and cheese from raw milk. The capital of LACPOL invested in this factory is 99 %, while that of the dairy union is 1 %. This factory started operation in 1988 and its facilities are relatively new. Although the capacity of the raw milk receiving facility is 500 thousand ton/y, raw milk of 200 thousand ton/y is received for production. The sanitation management status is lower than that in Japan, and as a result this factory could not acquire the license of export to the EU.
Since the number of dairy farmers located near by has decreased, it seems difficult for them to obtain the raw milk.

a. Energy management status

Since this factory was constructed 10 years ago and its facilities are new, there are few improvement points for the manufacturing facilities. Energy intensity management is being implemented. There are two spray dryers that consume large amount of steam are utilized alternately. Data on energy intensity is available, but it is not used for energy conservation activities .

b. Energy conservation potential

The energy intensity in 1997 was 9,000 MJ/t, which indicates that the factory has a 43 % energy conservation potential if 5,100 MJ/t of the excellent factory is used as the benchmark. Enhancement of energy management and investment for facility improvement based on the payback period within 3 years are estimated to allow a 17 % energy conservation saving.

Step 1 Energy Conservation Measures

Recommended measures include improvement of the air ratios of the boilers, installation of air pre-heaters for the boilers, stopping of the operation of one of the mixers used as part of the waste water treatment facilities, and connection of the air compressors. The implementation of these measures is estimated to achieve a saving of 8 % in both fuel and electricity consumption.

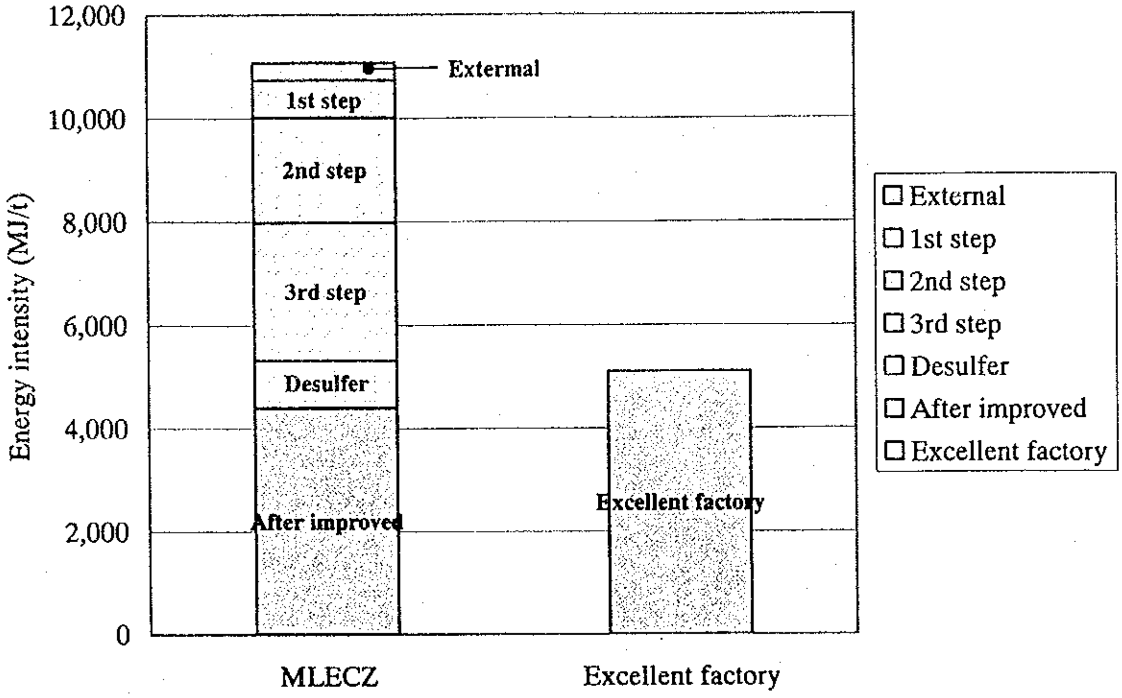
Step 2 Energy Conservation Measures

Recommendations include switching of the sterilization of milk for powdered milk processing to the UHT method, use of one spray drying system, improvement of the refrigeration system, control of the rotational speed of the boilers' exhauster, and improvement of the indoor lighting. It is estimated that these measures can achieve savings of 24 % in fuel and 16 % in electricity.

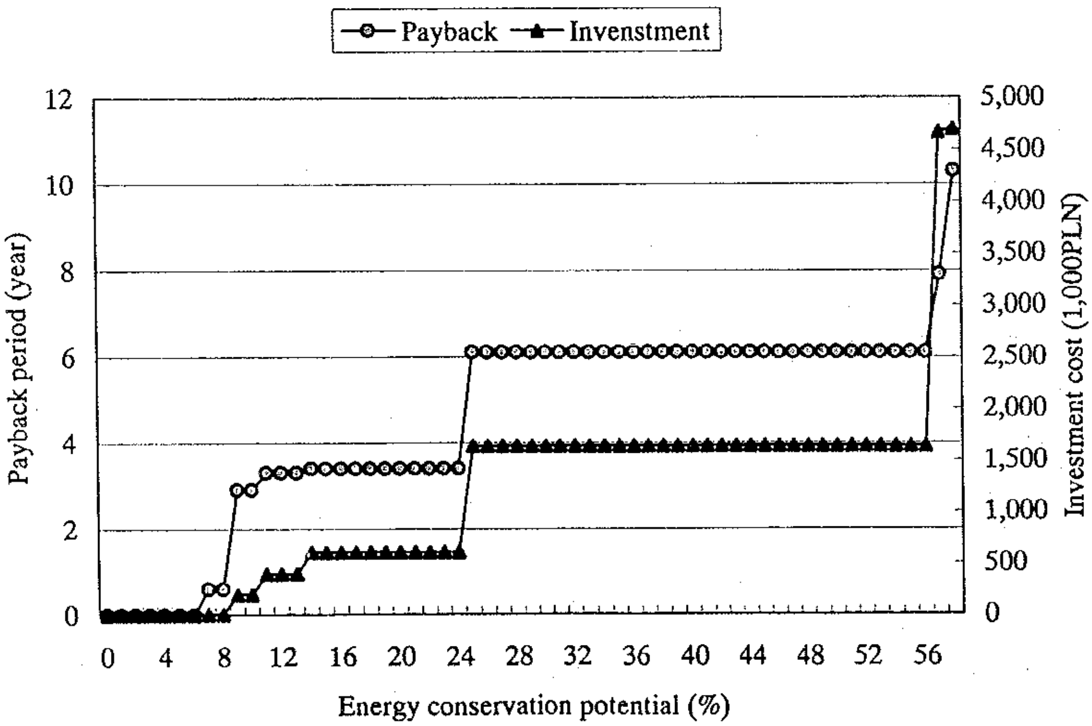
Step 3 Energy Conservation Measures

In view of the fact that natural gas will be supplied to the plant from 2003, in-depth consideration has been given to the feasibility of the adoption of gas-fired boilers and a back-pressure stream turbine power co-generation system. Our conclusion is that this would reduce energy consumption by approximately 20 %. However, as the price of natural gas per unit of calorific value in 2003 is expected to be 2.5 times that of coal, the adoption of these measures would involve a very long period for recovery of the necessary investment. This method has thus been deemed difficult to put into practice on a commercial level. It is recommended that consideration of these matters be continued, in order to respond appropriately to changes in energy prices and the regulatory environment.

MLECZ Energy Conservation Potential



MLECZ Conservation Potential



8.2 Current Status of Energy Consumption by Energy-consuming Equipment

During factory study, the status of energy consumption by the following energy consuming equipment was surveyed:

a. Lighting
b. Air compressor
c. Motor
d. Transformer
e. Factory space heating
f. Boiler
g. Heating furnace

(1) Lighting

Table 8.3 shows the energy conservation potential for lighting in each plant.
For lighting in the plants, fluorescent lamps and mercury lamps were used indoors. Mercury lamps are installed for outdoor lighting. No incandecent lamps are used. As shown in Table 8.5, power consumption for lighting in the factory accounts for 2 % or more, which indicates that lighting has an approximately 28 % energy consurption potential.

Energy conservation measures proposed for lighting are as follows:

a. Replacing fluorescent lamps with high-frequency fluorescent lamps

This is estimated to allow a 40 % electricity saving.

b. Replacing mercury lamps with high-pressure sodium lamps

This can be implemented at places which involve no problem with color rendering performance. This measure is estimated to achive an approximately 40 % energy saving

c. Lowering the height of lighting appliances

If the height is reduced from 6 m to 4 m, a 50 % or more energy saving can presumably be achieved because illuminance is in reverse proportion to a square of the distance from the light source.

As shown in Table 8.3, replacing with high-efficiency lighting appliances can lead to approximately 20 % energy conservation but the payback period is 5 to 15 years, which is significantly long. For outdoor lamps that are lit for 8 to 12 hours, the payback period is long. Hence it is recommended to replace with high-efficiency lighting appliances at the timing of changing the existing lighting.

In most factories surveyed, turning off of the lamps in daytime is implemented according to the instruction given by the managers. In some factories, however, outdoor lamps were left lit in daytime. Indoor lights were found lit even at places where sufficient luminance is obtained by natural light from a window. Education for raising employees' awareness regarding energy conservation will be necessary. As a method, the facilities should be improved in order to allow automatic turning on/off of lights with timers.

In contrast, turning off of the lamps was so completely implemented in some factories as to make walking difficult, and some workplaces failed to meet the luminance standard. It is advisable to manage the turning on/off of lighting by selecting equipment according to the Poland's illuminance standard.

Other recommended measures include enhancement of maintenance, such as periodical cleaning of lighting apparatuses without leaving them soiled, and cleaning of the skylight.

(2) Air compressor

Table 8.3 shows the energy conservation potential for the air compressor in each plant. Two types of air compressors are in use: the reciprocal compressor and turbo compressor. As shown in Table 8.5, the air compressors in the factory have a 17 % electricity share, suggesting that they have a 36 % energy conservation potentitial.

The energy conservation measures for air compressors are as follows:

a. Air flow rate control with the suction vane of the turbo compressor

Air flow control through rotational speed control cannot be applied to the turbo compressor. With air flow rate control using the suction vane, the electricity consumption can presumably be reduced by 10 %.

b. Reducing the compressor's discharged air pressure

The discharged air pressure should be made as low as possible depending on the air pressure used in the plant. It is estimated that if the pressure is reduced by 0.1 MPa, electricity can be saved by 6 %.

c. Changing the compressor from the centralized type to the distributed type

Although centralization of large compressors may be advantageous if the compressed air volume used is constant, it is preferable to distribute small compressors in each workshop if load variation is large.

d. Adoption of a screw compressor

Upon renewal of a large turbo compressor, it is recommended to consider the use of a screw compressor allowing air flow rate control by rotational speed control in case of frequent load fluctuations

e. Control of the number of compressors according to load fluctuations

Regarding a system discharging excess air to the atmospheric air to cope with load fluctuation, it is recommended to employ control of the number of compressors by ON/OFF control of compressors and change to the small reciprocal compressor unloaded operation system.

f. Countermeasure for air leakage

A large amount of air leakage was found at any of the factories surveyed. It is recommended to check for any air leakage on factory shut-down days, etc. in order to prevent air leakage as much as possible.

As shown in Table 8.3, the payback period for air compressor energy conservation measures is within 4 years. Therefore, these measures are easy to implement.

(3) Motor

Table 8.3 shows the energy conservation potential for motors in each plant. For motors, standard-type induction motors were adopted. No cases of using high-efficiency motors could be observed.
As shown in Table 8.5, the motors in the factory have a 37 % electricity share, thus suggesting that they have an appoximately 3 % energy conservation potential.

Energy conservation measures proposed for motors are as follows:

a. Output of motor load machines

It is necessary to check whether the output of devices connected to motors, such as blowers and pumps, is proper with particular regard to excessive flow rate and pressure. Operating them at a proper value in due consideration of factors, such as factory operation, is recommended.

b. Motor rotational speed control

It is recommended to apply rotational speed control by installing inverters for low-load running motors used for fluid feeders such as the pump and fan.
For example, if an inverter is installed for the motor of a fan running at a motor load of 80 %, the electricity consumption can supposedly be saved by 40 %.

c. Motor replacement

Large motors running under low load should be replaced with small motors.

The induction motor used in the factory results in poor efficiency when the load is low. As a recommended countermeasure, the motor with an excessive output should be replaced with a small motor, or the rotational speed control system should be adopted. As shown in Table 8.3, the payback period for motor replacement is long. It is therefore difficult to implement motor replacement. On the other hand, the installation cost for the inverter is lower because of advanced electronic control technology, making its use easy.

(4) Transformer

Table 8.3 shows the energy conservation potential of transformers in each factory audited.

Although production of each transformer in the factory was checked, transformers with poor design efficiency were not found in particular. The power factor varied largely depending on factories surveyed this time: Approximately 95 % of the factories had a good power factor, while about 85 % had a poor power factor.
As shown in Table 8.5, the energy conservation potential of the power receiving transformers in the factory is estimated at 1.2 %.

a. Integration of transformers

As our recommendations, if multiple low-load transformers are installed, the secondary side loads of the transformers should be integrated into one or several transformers and the primary side of transformers with no load should be shut off.

Among the low-load transformers, some were installed during construction according to the future expansion plan, while the others are excessive in terms of capacity as a result of reduction of the production volume. These transformers should be used through examination and elaboration on integration/abolition so that they can be used as the transformers with proper capacities according to the future production plan. Replacement with small-capacity transformers will be difficult in terms of the payback period. In Poland, the electricity contract does not strictly stipulate the penalty provision against reduction in power factor. Therefore, installation of a power factor improving capacitor is not so popular at factories where the power factor is low. The electric power contract in Poland stipulates that penalty is imposed only when the power factor is tan f < 0.4 (equivalent to cos f < 0.86). There is thus no bonus or benefit resulting from the improvement of power factor.

(5) Factory space heating (Air -conditioning)

This factory survey was performed in July through October, and it was therefore impossible to investigate the factory space heating implementation status during the high-load season. In three factories, the space heating status under a low-load condition was investigated but the data allowing the energy conservation potential to be quantified could not be collected. Energy conservation measured proposed for space heating in the factory are as follows:

a. Prevention of outer air entry into the factory building

Measures such as repair of broken window glass and prohibition of leaving the door open are implemented in general. Although adjustment of the roof ventilation hole opening degree is not carried out, this should be implemented based on the standard on the number of ventilation times.

b. Heat insulation enhancement for the factory building

Some factories are adopting pair glass or transparent laminate plastic panel for window glass. The overall heat tranfer of a laminate transparent plastic panel is approximately 50 %, which is almost the same as that of a pair glass.

c. Utilization of warm air at elevated places in the factory building

Warm air stays at an elevated position in a building having high roof and ceiling. As a recommended countermeasure, fans or jet nozzles should be installed at an elevated position in order to reduce the temperature difference between the floor surface and the elevated places.

d. Enclosure for the work space

A work space should be set up in the plant building. As a recommended countermeasure, this area from the floor to the ceiling should be enclosed with wall members and synthetic resin sheets to prevent warm air from escaping. Some factories have implemented this countermeasure.

e. Adoption of local space heating

It is recommended to use localized heating for operators, along with heating the entire factory, when the work space is limited. In this case, local heating with far infrared ray is effective.

Although space heating in the plant building is not implemented if heat generating elements are in the building for iron and steel making, non-metallic materials, etc., energy for space heating accounts for more than 30 % of the total energy annually used in machine manufacturing, chemical industries, etc.

In Poland, it is required by law that the room temperature of the workshop for workers be kept at 16 °C or higher. Recommended measures include setting up an appropriate standard depending on the case in order to reduce the energy consumption for heating.

(6) Boiler

Table 8.4 shows the energy conservation potential for boilers in each factory.
Most boilers used in the targeted factories are the coal-fired furnace flue tube steam boiler, coal-fired stoker type water tube steam boiler, and hot water boiler. Small-size boilers installed include once-through hot water boiler and fuel oil-fired once-through steam boiler.
For the dust collector, cyclone type dust collectors are installed in some factories; however electrical dust collectors and bag filters with high dust collection efficiency are not installed. Neither exhaust smoke desulfurizing equipment nor exhaust smoke denitrifying equipment are available.
As shown in Table 8.5, the boilers in the factory consume 42 % of the total heat energy, suggesting that they have a 7 % energy conservation potential.

Energy conservation measures proposed for boilers are as follows:

a. Improvement of the combustion air ratio for the coal-fired boiler

The coal-fired stoker type water tube boiler is run at an air ratio of 2 to 6. In other words, an air volume twice to six times larger than necessary is used and the excess air results in the exhaust gas heat loss. As a recommended countermeasure, the air ratio for operation should be 2 or lower. For example, if the air ratio is reduced from 6 to 3, the fuel consumption is expected to decrease by 25 %. For combustion at an air ratio of 3 or lower, black smoke goes up out of some smoke stacks of some boilers. Therefore, enhancement of combustion management and arrangement of the dust collector are also recommended.

b. Maintenance of the air preheater

Many boilers have efficiency of the air preheater declining due to adhesion of coal dust on the heating surface of the air preheater for combustion. By cleaning the heating surface, efficiency can presumably be recovered and the fuel volume used can be reduced

c. Improvement of the coal feeder

Many coal-fired boilers are equipped with a stoker type coal feeder but this cannot adequately cope with load fluctuation. If a stoker type coal feeder with a spreader is adopted, the adjustable range for load fluctuation can be improved, thus allowing operation at an air ratio of 1.5.

In recent years, natural gas-fired boilers and fuel oil-fired boilers are increasing. Although only one or two years have passed since the start of operation, they are running in a good condition at an air ratio of 1.3 to 1.5.
It is recommended that the coal-fired boiler attain combustion at a low air ratio and a dust collector with high dust collection efficiency be installed in order to clear the emission standard against soot, SOx, CO2, etc. when the emission standard is lowered in the future Many factories have a plan to scrap the coal-fired boiler and adopt a natural gas-fired boiler, considering a possible increase in the air pollutant fee (Emission fee) for emission matters from the coal boiler and an increase in the air pollutant penalty (Emission fine). Since the price of natural gas per unit heating value is twice higher than that of coal, installation of a new natural gas-fired boiler requires a payback period of 5 years or longer even if the reduction in the emission fee or fine on the coal boiler is taken into account. However, if installation of an exhaust smoke desulfurizing equipment for the coal-fired boiler is considered, the payback period will be within 5 years. Therefore, renewal to a natural gas-fired boiler is considered acceptable in terms of cost-benefit.
Such replacement with a natural gas-fired boiler is expected to gradually increase.

(7) Heating furnace

Table 8.4 shows the energy conservation potential for the billet reheating furnace in the rolling mill, the steel product heating furnace in the forging mill, and tar distilling heating furnace in the chemical plant in the iron and steel making industry.
The billet heating furnace and the forge-heating furnace in the rolling mill in the iron and steel making industry use a system that directly heats billets with combustion gas using natural gas as fuel. The tar heating furnace employs an indirect heating system that heats tar in the heating tube, and the fuel used is coke oven gas.

As shown in Table 8.5, the heat energy share of the heating farnaces in the factory is estimated at 65 %, suggesting that they have a 26 % energy conservation potential.

Energy conservation measures recommended for heating furnaces are as follows:

a. Improvement of the combustion air ratio

The billet reheating furnace in the rolling mill is running at an air ratio of 1.2 to 1.8. As our recommended measure, improvement should be made so that the air ratio will be 1.1 to 1.3. If the air ratio is reduced from 1.8 to 1.3 at 850 °C of exhaust gas temperature, the fuel volume saved is estimated at approximately 15 %.

b. Reinforcement of furnace body heat insulation

Enhancement of heat insulation allows reducing the heat loss due to radiation from the furnace body. Heat insulation with ceramic fiber is effective for batch furnaces such as the forge-heating furnace. On batch furnaces, heat accumulation loss of the fire-resistant heat insulation material is large in addition to the loss of heat emission from the furnace body. Thus the use of light-weight ceramic fiber is recommended. This measure is being implemented for forge-heating furnaces.

c. Establishing the heat holding operation criteria

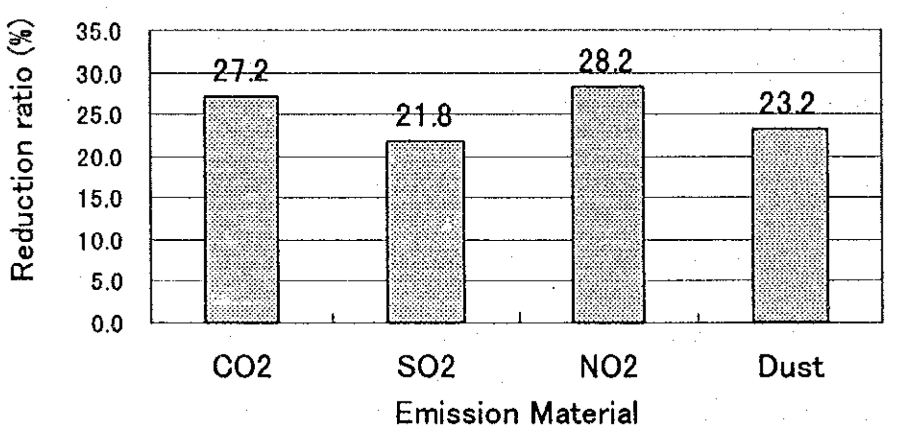
In order to reduce the fuel used while the heating furnace stops or is holding heat, establishing the heat-holding criteria is recommended.

As shown in Table 8.4, improvement of the air ratio brings about a significant energy conservation effect. Improvement of the measuring equipment and controller for adjustment of air ratio is considered feasible with a payback period within 3 years. For enhancement of heat insulation with ceramic fiber, the payback period is 5 to 6 years. Therefore, these measures should be implemented in order of priority.

8.3 Estimation of Environment Improvement Effects by Energy Conservation

In energy audits in 15 factories, the discharged volumes of CO_2, SO_2, NO_2, and dust were calculated based on the fuel and electricity consumptions. The reduced amounts of CO_2, SO_2, NO_2, and dust were estimated from the amounts of fuel and electricity reduced as a result of implementing energy conservation measures. Also, a reduction in air pollutant fee (Emission Fee) for emission materials such as CO_2 stemming from implementation of energy conservation measures was calculated and added to the cost as an effect of energy conservation measures in order to calculate the payback period for the improvement project.
As shown in Figure 8.1, emission matters such as CO_2 are esimated to decrease by 27 %. Figure 8.1 shows the reduction amount of each emission material.

Figure 8.1 Reduction Ratio by Emission Material



The payback period for investment in improvement projects was calculated by adding the reduction in the air pollutant fee (Emission Fee) to the effect of energy conservation in monetary terms. As a result the reduction in the payback period is estimated at only 1-4 %. Thus the reduction in the air pollutant fee (emission fee) will provide no significant incentives to the factory.

The following coefficients were used for the amounts of CO_2, SO_2, NO_2 and dust generated from fuels, electricity and CO_2. Pollutant emissions from the plant that supplies steam and hot water are not included in the calculation.

Energy	Unit	CO_2	SO_2	NO_2	Dust
Gas fuel	kg/GJ	55,400	0.004	0.056	0.001
Solid fuel	kg/GJ	94,400	0.660	0.175	0.143
Liquid fuel	kg/GJ	72,800	0.140	0.118	0.002
Electric power	kg/MWh	7.318	0.223	0.069	0.012

Air pollutant fee (Emission fee) and air pollutant penalty (Emission fine) which must be paid when an air pollutant including CO_2 is emitted are as follows. The emission fine is 100 times as large as emission fee.

Fee	Unit	CO_2	SO_2	NO_2	Dust
Air pollutant fee (Fee)	PLN/kg-pollutant	0.00015	0.3	0.3	0.2
Air pollutant penalty (Fine)	PLN/kg-pollutant	0.015	30	30	20

Table 8.3 Summary of Energy Conservation Potential of Electric Equipment (1/2)

Electricity: 0.172 PLN/kWh
1PLN=35yen

No.	Sector	Item	Energy Conserv. Potential Electricity MWh/y	1000 PLN/y	Investment cost 1000 PLN	Payback period year
Lighting equipment						
Step 1						
1	Steel	Turning off unnecessary lamps	7	1	0	0.0
2	Machine	Lower fluorescent lamps to 4 m	2	0.3	0	0.0
3	Chemical	Turning off unnecessary lamps	29	5	0	0.0
		Subtotal	38	6	0	0.0
Step 2						
4	Steel	Change mercury lamp to sodium lamp	736	127	857	6.8
5	Steel	Change mercury lamp to sodium lamp	3,360	578	1,971	3.4
6	Chemical	Change mercury lamp to sodium lamp	210	36	34	0.9
7	Chemical	Change mercury lamp to sodium lamp(Outside)	82	14	217	15.4
8	Machine	Change mercury lamp to sodium lamp	108	19	140	7.5
9	Machine	Change fluorescent lamp to high frequency lamp	77	13	252	19.0
10	Machine	Change to high efficiency lamp	616	106	1,500	14.2
11	Glass	Change mercury lamp to sodium lamp(Outside)	135	23	47	2.0
12	Non metal	Change mercury lamp to sodium lamp(Outside)	4	1	9	13.1
13	Food	Change mercury lamp to sodium lamp(Outside)	9	2	15	9.7
14	Food	Improvement of lighting in building	92	16	10	0.6
15	Food	Change mercury lamp to sodium lamp(Outside)	17	3	30	10.3
		Subtotal	5,446	937	5,082	5.4
		Total (Step 1 + Step 2)	5,484	943	5,082	5.4
Air compressor						
Step 1						
1	Steel	Improvement of operation system	296	51	57	1.1
2	Steel	Reduction of air leakage	743	128	0	0.0
3	Machine	Reduction of air leakage	4,800	826	0	0.0
4	Glass	Reduction of pressure	1,505	259	0	0.0
5	Food	Connection of compressor	206	35	10	0.3
		Subtotal	7,550	1,299	67	0.1
Step 2						
6	Steel	Installation of small compressor	365	63	250	4.0
7	Steel	Improvement of pressure control of turbo compres	772	133	286	2.2
8	Chemical	Installation of small compressor in each shop	880	151	250	1.7
9	Machine	Reduction of pressure	1,170	201	43	0.2
10	Machine	Reduction of pressure	140	24	20	0.8
11	Machine	Installation of small compressor	3,832	659	130	0.2
12	Machine	Improvement of compressor	600	103	143	1.4
		Subtotal	7,759	1,335	1,122	0.8
		Total (Step 1 + Step 2)	15,309	2,633	1,189	0.5

Table 8.3 Summary of Energy Conservation Potential of Electric Equipment (2/2)

Electricity: 0.172 PLN/kWh
1PLN=35yen

No.	Sector	Item	Energy Conserv. Potential Electricity MWh/y	1000 PLN/y	Investment cost 1000 PLN	Payback period year
Motor						
Step 2						
1	Steel	Installation of inverter control	134	23	124	5.4
2	Steel	Installation of inverter control	2,600	447	1,237	2.8
3	Steel	Installation of inverter control for blower motor	239	41	129	3.1
4	Chemical	Installation of inverter control for pump motor	355	61	154	2.5
5	Chemical	Installation of inverter control for boiler motor	195	34	47	1.4
6	Glass	Installation of inverter control	298	51	197	3.8
7	Machine	Installation of inverter control	257	44	189	4.3
8	Machine	Installation of inverter control	3,000	516	1,457	2.8
9	Food	Installation of inverter control	385	66	189	2.9
10	Food	Replacement of motor	13	2	11	4.9
11	Food	Installation of inverter control	333	57	283	4.9
		Total	7,809	1,343	4,017	3.0
Transformer						
Step 1						
1	Machine	Rearrangement of transformer	46	8	0	0.0
2	Chemical	Reduction of capacity	34	6	0	0.0
3	Chemical	Unification of transformers	126	22	40	1.8
4	Food	Adjusting of voltage	33	6	0	0.0
5	Food	Stop of transformer operation	9	2	0	0.0
6	Food	Cutoff of transformer breaker	1	0	0	0.0
		Total	249	43	40	0.9

Table 8.4 Summary of Energy Conservation Potential of Heat Equipment

Natural gas: 0.514 PLN/m3N
Coal: 170PLN/t   1PLN=35yen

No.	Sector	Item	Energy Conserv. Potential Fuel GJ/y	1000PLN/y	Investmment cost 1000PLN	Payback period year
Boiler						
Step 1						
1	Steel	Improving of air ratio	8,198	63	0	0.0
2	Machine	Improving of air ratio	16,765	130	0	0.0
3	Chemical	Improving of air ratio	52,866	409	0	0.0
4	Non-meta	Improving of air ratio	5,542	43	0	0.0
5	Food	Improving of air ratio	6,244	48	0	0.0
6	Food	Improving of air ratio	1,842	14	0	0.0
7	Food	Improving of air ratio	8,063	62	0	0.0
8	Food	Maintenance of air preheater	2,343	18	0	0.0
Subtotal			101,863	193	0	0.0
Total			101,863	193	0	0
Heating furance						
Step 1						
1	Steel	Improvement of air ratio of shape mill	5,614	81	0	0.0
2	Steel	Imrovement of holding heat standard	5,012	73	0	0.0
3	Steel	Improvement of operation standard in low load	12,311	178	0	0.0
4	Steel	Improvement of air ratio of plate mill	1,800	26	0	0.0
5	Steel	Reinforcement of close of opening	2,342	34	57	1.6
6	Steel	Improvement of air ratio of bar mill	191,490	2,773	0	0.0
7	Steel	Improvement of air ratio of forging(Heat)	162,744	2,356	4,000	1.6
		Improvement of air ratio of forging(Electricity)	1,499MWh/y	258	0	0.0
Subtotal			381,313	5,779	4,057	0.7
Step 2						
8	Steel	Insulation of ceramic fiber of shape mill	12,631	183	857	4.6
9	Steel	Insulation of ceramic fiber of plate mill	7,169	104	571	5.5
10	Steel	Insulation of ceramic fiber of bar mill	37,079	537	1,143	2.1
11	Steel	Insulation of ceramic fiber of bar mill 2	84,825	1,228	1,429	1.1
12	Steel	Improvement of openings	24,889	360	143	0.3
Subtotal			166,593	2,412	4,143	1.7
Step 3						
13	Steel	Introduction of hot charge rolling	33,483	485	875	1.8
14	Steel	Increase of hot charge rolling ratio	170,157	2,464	7,143	2.8
Subtotal			203,640	2,948	8,018	2.7
Total			751,546	11,140	16,218	1.4

Table 8.5 Energy Consumption Share and Energy Conservation Potential Ratio of Energy Consuming Equipment

No.	Equipment	Energy consumption of factories (A) Unit		Energy consumption of equipment (B)	Share (B/A*100) %	Energy conservation potential (C)	Ratio (C/B*100) %	No. of factory
1	Lighting	MWh/y	846,961	19,777	2.3	5,482	27.72	11
2	Air compressor	MWh/y	245,412	42,606	17.4	15,309	35.93	10
3	Motor	MWh/y	886,894	327,232	36.9	7,809	2.39	15
4	Transformer	MWh/y	716,487	21,495	3.0	249	1.16	12
5	Boiler	GJ/y	3,444,492	1,431,612	41.6	101,863	7.12	11
6	Heating furnace	GJ/y	4,099,071	2,658,694	64.9	703,800	26.47	2

Table 8.6 Air Pollutant Fee Reduction by Energy Conservation

Industry sector	No.	Factory name	Fuel saving (GJ/y)	Electricity saving (MWh/y)	Reduction of emission from fuel and electricity: CO2 (t/y)	SO2 (t/y)	NO2 (t/y)	Dust (t/y)	Reduction of emission fee: CO2 1000PLN/y	SO2 1000PLN/y	NO2 1000PLN/y	Dust 1000PLN/y	Total 1000PLN/y	Reduction rate(%)	Payback period: Eco-Environ (year)	Economical (year)	Reduction ratio (%)
Steel-Making Industry	1	Labedy	135,024	5,018	7,746.6	1.7	121.9	0.2	1.2	0.5	36.6	0.0	38.3	19.7	1.55	1.57	1.4
	2	Ostrowiec	1,120,495	54,611	59,005.5	10.7	928.7	1.4	8.9	3.2	278.6	0.3	290.9	28.7	1.58	1.59	1.1
	3	Lacznikow	58,899	11,726	7,018.3	72.5	-25.9	15.3	1.1	21.8	-7.8	3.1	18.1	23.4	2.33	2.35	0.7
Chemical Industry	4	Blachownia	274,697	2,409	14,789.2	1.6	33.6	0.3	2.2	0.5	10.1	0.1	12.8	33.1	1.29	1.30	0.3
	5	Poch	74,195	311	7,139.8	49.0	23.0	10.6	1.1	14.7	6.9	2.1	24.8	23.0	1.66	1.73	4.1
	6	Boruta	8,086	1,353	9.9	0.3	0.1	0.0	0.0	0.1	0.0	0.0	0.1	0.5	1.59	1.59	0.0
Machine Manufacturing Industry	7	Ursus	161,352	35,856	5,047.3	34.2	13.4	6.1	0.8	10.3	4.0	1.2	16.3	6.0	11.31	11.33	0.2
	8	Star	124,400	12,689	4,592.1	3.1	14.6	0.2	0.7	0.9	4.4	0.0	6.0	18.8	26.90	26.94	0.1
Non-Metallic Industry	9	Wolomin(A+B	483,006	-13,831	26,822.3	5.1	158.1	1.7	4.0	1.5	47.4	0.3	53.3	60.7	3.89	3.94	1.2
	10	Silikaty	23,461	4	2,210.1	15.5	4.7	3.4	0.3	4.6	1.4	0.7	7.1	30.9	1.21	1.26	4.0
Food Processing Industry	11	Olvit	41,273	33	1,874.4	3.6	3.0	0.1	0.3	1.1	0.9	0.0	2.3	14.0	0.77	0.77	0.2
	12	Koscian Meat	8,194	264	455.9	0.1	0.5	0.0	0.1	0.0	0.1	0.0	0.2	15.4	2.63	2.63	0.1
	13	Lubmeat	15,603	544	1,476.9	10.4	2.8	2.2	0.2	3.1	0.8	0.4	4.6	27.4	3.47	3.51	0.9
	14	Obrzanska	4,753	62	449.1	3.2	0.8	0.7	0.1	0.9	0.3	0.1	1.4	12.3	1.73	1.79	3.0
	15	MLECZ	61,267	6,527	9,533.1	104.2	22.5	22.3	1.4	31.2	6.7	4.5	43.9	109.2	4.95	5.19	4.7
		Sum	2,594,705	117,576	148,170.3	315.2	1,301.8	64.4	22.2	94.6	390.5	12.9	520.2	26.6			
		Current energy consumption	8,209,307	890,189													
		Current emission from fuel & electricity (t/y)			544,470	1,449	4,608	277									
		Reduction ratic of energy & emission (%)	31.6	13.2	27.2	21.8	28.2	23.2									

9. GUIDELINE FOR
ENERGY CONSERVATION IMPLEMENTATION AND MANUAL FOR ENERGY CONSERVATION AUDIT MEASUREMENT

9. GUIDELINE FOR ENERGY CONSERVATION IMPLEMENTATION AND MANUAL FOR ENERGY CONSERVATION AUDIT MEASUREMENT

9.1 Guideline for Energy Conservation Implementation

Part IV of this Report contains the energy conservation implementation methods for each targeted industrial sector to be made available as a useful guide to the implementation of energy conservation. Based on the factory audit results, this guideline was prepared in due consideration of the proven approaches and successful cases implemented in Japan. The content of the guideline is believed to be helpful as a guidebook for the Polish counterparts to implement factory audits, seminars, etc.

The guideline for each industrial sector contains:

- Characteristics of energy consumption by each industrial sector
- Manufacturing processes and major energy facilities
- How to proceed with energy management
- Method for energy conservation implementation

The targeted industrial sectors and energy utilization equipment are as follows:

(1) Industrial sector

a. Iron and steel making industry
b. Chemical industry
c. Machine manufacturing industry
d. Non-metallic materials industry (glass and silica blocks)
e. Food processing (vegetable oil, meat and dairy products)

(2) Energy utilization equipment

a. Lighting
b. Air compressor
c. Motor
d. Transformer
c. Factory space heating (Air conditioning)
f. Boiler
g. Heating furnace

9.2 Measurement Manual for Energy Auditing

Part V of this Report constitutes a measurement manual for implementation of energy audits for each targeted industrial sector and energy-consuming equipment. This manual is intended to help Polish engineers and consultants to collect measurement data and carry out factory audits by themselves while they are implementing the results of factory audits.

The measurement scheme for each industrial sector contains the measurement items, measurement points, measurerement time and measurement data processing method for each process equipment. The manual covers the following items.

(1) Auditing procedure

(2) Points to be noted in auditing

(3) Grasping the factory overview

(4) Description of the measurement schedule

(5) Description of the measurement equipment

(6) Measurement data processing

(7) Explanation of heat balance sheet

(8) Measurement scheme for each industrial sector

   a. Iron and steel making industry
   b. Chemical industry
   c. Machine manufacturing industy
   d. Non-metallic materials industry
   e. Food processing industry

(9) Energy utilization equipment

   a. Lighting
   b. Air compressor
   c. Motor
   d. Transformer
   e. Fan, Blower
   f. Pump
   g. Boiler
   h. Steam line

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