11-12 Cost of Measures for Energy Efficiency Promotion

Budget type costs were estimated for the two measures, "Improvement of heat energy efficiency in the steam and steam condensate recovery system" and "Improvement of steam trap system". As for "Decreasing heat loss in the thermal insulation system", costs required to repair insulation that was pointed out could be covered by ordinary maintenance costs. For the measure of "Recovery of electrical power from energy loss in steam control valve", modification of the tarriff system and building the new power transmission system from the factory to TNB's grid should be the first step. Upon due consideration of these activities, cost estimation should be made on the appropriate estimation basis.

(1) Improvement of Heat Energy Efficiency in Steam and Steam Condensate Recovery System

- Utilization of heat energy in boiler exhaust gas
- Improvement of steam condensate recovery (13.7 t/h)

	10^3 Yen
1. Economizer (heat transfer area: 271 m^2)	7,000
2. Economizer Installation work (air-duct, BFW piping, insulation, painting)	4,500
3. Condensate line piping (840 inch-m, carbon steel)	4,500
4. Condensate tank (carbon steel, 10 m^3)	1,200
5. Tank insulation	2,000
6. Condensate recovery pump / motor (capacity: 30 t/h)	500
7. Civil, electrical, election, insulation, others	3,800
TOTAL	23,500

Item 1: Utilization of heat energy in boiler exhaust gas

Installation of BFW Heater after the existing Air Heater to recover the heat loss in the boiler exhaust gas

BFW Heater Basic Conditions:

	Temp.(°C)		Press.(bar)		Flow rate
	Inlet	Outlet	Inlet	Outlet	
BFW	103	119	21	21	43.3 t/h
Exhaust Gas	225	160	Atm	Atm	32,620 Nm^3/h

Item 2: Improvement of steam condensate recovery

Installation of steam condensate recovery facilities to recover condensate from 22 out of 43 non-recovering steam traps

Note: Total traps ((64)) recovering traps (21), target traps (22)

(2) Replacement of Failed Steam Trap

- Substitution of 10 failed (blowing, leaking) steam traps

	10^3 Yen
1. Installation of steam trap	326
TOTAL	326

11-13 Potential of Energy Efficiency Promotion

Effects of energy efficiency promotion are summarized below for the two measure of which budget type costs were estimated in the previous section.

(1) Improvement of Heat Energy Efficiency in Steam and Condensate Recovery System

- Utilization of heat energy in boiler exhaust gas – Improvement of steam condensate recovery	Fuel oil reduction 2.78 – 2.58 = 0.2 ton/hr (1,600 ton/year)

(2) Replacement of Hailed Steam Traps

- Replacement of leaking and blowing traps	Prevention of steam leaks: 4,113 US$/year

11-14 Benefit of Measures for Energy Efficiency Promotion

11-14-1 Energy Prices for CSR

The energy prices of CSR could not be obtained from CSR, as these are corporate secrets. Accordingly, the study team assumed the prices for study purposes, as Table 11-14 shows.

Table 11-14 Assumed Energy Price

	Unit Price
Medium Fuel Oil	323.5 RM/ton
Generated Steam	30 RM/ton

11-14-2 Benefits of Measures

The benefits of the measures are estimated and the results are summarized in Table 11-15.

Table 11-15 Estimation of Benefit from Measures

Measures	Benefit, Rm/year
Improvement of Heat Energy Efficiency in Steam and Steam Condensate Recovery System	517,600
Replacement of Failed Steam Traps	15,629

11-15 Financial Evaluation of Measures

In this section, financial evaluations are made for the following measures requiring investment, in order to ascertain the financial feasibility of the measures.

- Improvement of Heat Energy Efficiency in Steam and Steam Condensate Recovery System
- Replacement of Failed Steam Traps

11-15-1 Premises for Financial Evaluation

Financial evaluations are made on the following premises.

1) Exchange rate: US$ 1 = RM 3.8 ; US$ 1 = JY 118
2) Project life: 15 years from the start of operation
   (5 years from the start of operation for the replacement of failed steam traps)
3) Corporate tax rate: 30 percent
4) Depreciation: The straight-line method is applied. The depreciation period is 15 years for the plant and machinery.
5) Fixed investment: Table 11-16 summarizes the fixed investment cost for the measures, which were obtained by converting the Japanese Yen values in the previous section.

Table 11-16 Fixed Investment Cost for Measures

Measures	Fixed Investment Cost (RM)
Improvement of Heat Energy Efficiency in Steam and Steam Condensate Recovery System	757,000
Replacement of Failed Steam Traps	10,498

11-15-2 Results of Financial Evaluation

Table 11-17 shows FIRROI before tax, FIRROI after tax and the payback period for the measures.

Table 11-17 Results of Financial Evaluation

Measures	FIRROI before tax	FIRROI after tax	Payback Period
Improvement of Heat Energy Efficiency in Steam and Steam Condensate Recovery System	68.4%	49.8%	2.0 years
Replacement of Failed Steam Traps	147.3%	103.1%	0.9 years

11-15-3 Conclusion of Financial Evaluation

According to the information obtained during the field survey, the lending rate in Malaysia has been ranging from 12 to 14% per annum recently. This rate could be regarded as an indication of the opportunity cost of capital in Malaysia.

Both measures are considered financially feasible from favorable FIRROIs much higher than the opportunity cost of capital, as well as sufficiently short payback periods under the conditions set for the study. These favorable results come from the relatively large benefit for the first measure and the small investment for the second measure.

11-16 Recommendations for Energy Efficiency Promotion

Based on the energy audit and subsequent study for CSR including the financial evaluation, the following measures are recommended for improving its energy efficiency.

(1) Improvement of Heat Energy Efficiency in Steam and Steam Condensate System

The energy audit revealed a rather high temperature of boiler flue gas and a low recovery rate of steam condensate in the steam and steam condensate system of CSR. It is recommended that the heat of boiler flue gas be recovered to increase the boiler feed water (BFW) temperature. For this purpose, it is necessary to install a BFW preheater for heating BFW coming from the existing deaerated BFW pump by flue gas coming from the existing air preheater. As for a measure to increase the recovery rate of steam condensate, the installation is recommended of a steam condensate recovery system, consisting of a condensate tank, a condensate recovery pump, and related piping. This measure is considered financially feasible under the conditions set for the study.

(2) Improvement of Steam Trap System

It was observed that 31 steam traps among the 64 installed in the steam-utilizing facilities were malfunctional due to blowing, leaking or blocking. It is recommended that blowing or leaking steam traps be replaced with new steam traps. As for the blocked or low-temperature traps, scheduled maintenance is recommended. This measure is considered financially feasible based on the financial evaluation.

(3) Decreasing Heat Loss by Thermal Insulation

During the energy audit, it was observed that some portions of straight lines, valves and flanges were not insulated. It is recommended that these parts be insulated to prevent heat loss.

(4) Power Generation to Recover Energy Loss from Steam Control Valve

Of the 50 ton/hour of steam generated by boilers, 20 ton/hour was depressurized by the steam control valve to low-pressure steam at 0.5 bar for heating purposes. According to a rough estimation by the study team, 750 kW of power could be generated by recovering the energy loss due to this depressurization. It is recommended that a supplementary turbine be installed to recover this energy loss, provided that the present tariff system is amended to allow CSR to supply excess electricity to outside users through TNB.

Chapter 12 Steel Mill (Amsteel Mills)

12-1 Characteristics of Minimill Subsector

The Minimill is a steel production process. The main products made by this process are rebar, section and wire rod, which are types of bar steel.
The Minimill consists of production plants including a steelmaking plant (electric arc furnace, ladle furnace and continuous casting machine) and a rolling mill plant (bar rolling mill and/or rod rolling mill) with auxiliary facilities such as an oxygen plant, compressed air plant, water treatment station, main receiving sub-station, shredder plant, analysis and inspection laboratory, maintenance shop, etc.

Total energy consumption of the minimill is generally 70 percent in the steelmaking plant (SMP); and 80 percent of electricity is consumed in the SMP.

Energy saving in the electric arc furnace has been achieved, together with efforts to increase productivity. Energy saving in an electric arc furnace includes (1) utilizing oxygen gas by means of oxy-lancing and oxy-fuel burners, (2) adoption of a large-scale furnace and a large-capacity transformer, (3) introduction of new technologies, EBT (eccentric bottom tapping system), ladle furnace operation, scrap preheating, DC (direct current) arc furnace system, and twin furnaces to most efficiently use the exhaust gas heat, for example, and (4) improvement of operational techniques such as long arc operation and foamy slag operation. Nowadays, the DC twin furnace operation is considered the most advanced furnace. In the rolling mill plant, energy use is reduced in the reheating furnace by adoption of hot charge operation together with improvement of the refractory, heat exchangers, combustion burners and combustion control. The slit rolling practice has also contributed to increased productivity.

12-2 Outline of Factory, Facilities and Flowsheet of Major Products

12-2-1 General

ASM is located in the Bukit Raja Industrial Estate, 30 km west of Kuala Lumpur. ASM's first rolling mill was constructed and commissioned in 1978. ASM is one of the largest and most technically sophisticated steel mills in the nation, and has one steel-making plant producing steel bars and wire rods. The capacity of the steel-making is 0.75 million tons per year, and that of rolling plant for steel bars and wire rods is 0.9 million tons per year. Currently, ASM supplies approximately one third of the nation's requirement of steel bars and wire rods. The company's paid capital was 671 million RM in 1997.

12-2-2 Outline of the Steel Works

(1) Grade of Steel

Grades of steel are as follows:

1) 5 % of production is low carbon grade,
2) 35% of production is medium carbon grade, and
3) 60% of production is re-bar grade for construction steel.

(2) Main Products

The products are as follows:

1) 120 to 130 square millimeter billets at 5.5 to 11.5 meters long,
2) 10 to 40 millimeter plain and deformed bars, and
3) 5.5 to 30.0 millimeter wire rods.

Production volumes of the past 5 years are shown in Table 12-1. Production is increasing year by year. Production from rolling mills exceeds billet production and the shortage of billets is compensated by imports from Poland.

Table 12-1 Production and Productivity for the Past Five Years

(Unit: tons per year)

No.	Product	1993		1994		1995		1996		1997	
		t/y	t/h	t/y	t/h	t/y	t/h	t/y	t/h	t/y	t/h
1	Billet	389,374	61	588,897	77	642,681	85	660,077	87	660,286	-
2	Rolling Mills										
	Rod Mill	282,890	38	303,105	53	261,771	44	321,698	53	369,464	-
	One	164,994	26	181,716	28	174,542	26	183,944	27	212,633	-
	Bar Mill One	209,640	38	257,640	41	272,168	41	284,698	45	312,972	54
	Bar Mill Two										

(3) Raw materials

The raw materials charged to the electric arc furnace (EAF) are all scraps.

(4) Layout of the Steel Works

Layout of the steel works is shown in Figure 12-1.

(5) Steel-making Plant (SMP)

The SMP has the following facilities.

1) Electric Arc Furnace (EAF)

   1 unit×85 tons/heat (Hereafter the word " heat " is used to mean molten steel.) with eccentric bottom tapping (EBT), an 80 MVA transformer, 1 oxygen lance manipulator, 3 jet burners

2) Ladle Furnace (LF)

   1 unit×85 tons/heat with 33 MVA transformer

3) Continuous Casting Machine (CCM)

   1 unit×6 strands for billets of 100 to 140 mm square and 4 to 11.5 meters long

4) Production of billet in 1997 : 660,300 tons

(6) Rolling Mill Plant (RMP)

The RMP consists of three rolling mills as shown below.

1) Rod mill 1

   Reheating furnace capacity is 65 metallic tons / hour with walking beams, oil fired burners

   1 unit×continuous rolling with 7 roughing stands, 8 intermediate stands, 12 finishing stands, shears, laying head, finishing facilities

   Production of wire rod in 1997 : 369,500 tons

2) Bar mill 1

   Reheating furnace capacity is 35 metallic tons / hour

   1 unit×continuous rolling with 15 stands, shears, slit rolling, cooling bed

   Production of bar in 1997 : 212,600 tons

3) Bar mill 2

   Reheating furnace capacity is 60 metallic tons / hour

   1 unit×continuous rolling with 17 stands, shears, , cooling bed

   Production of bar in 1997 : 313,000 ton

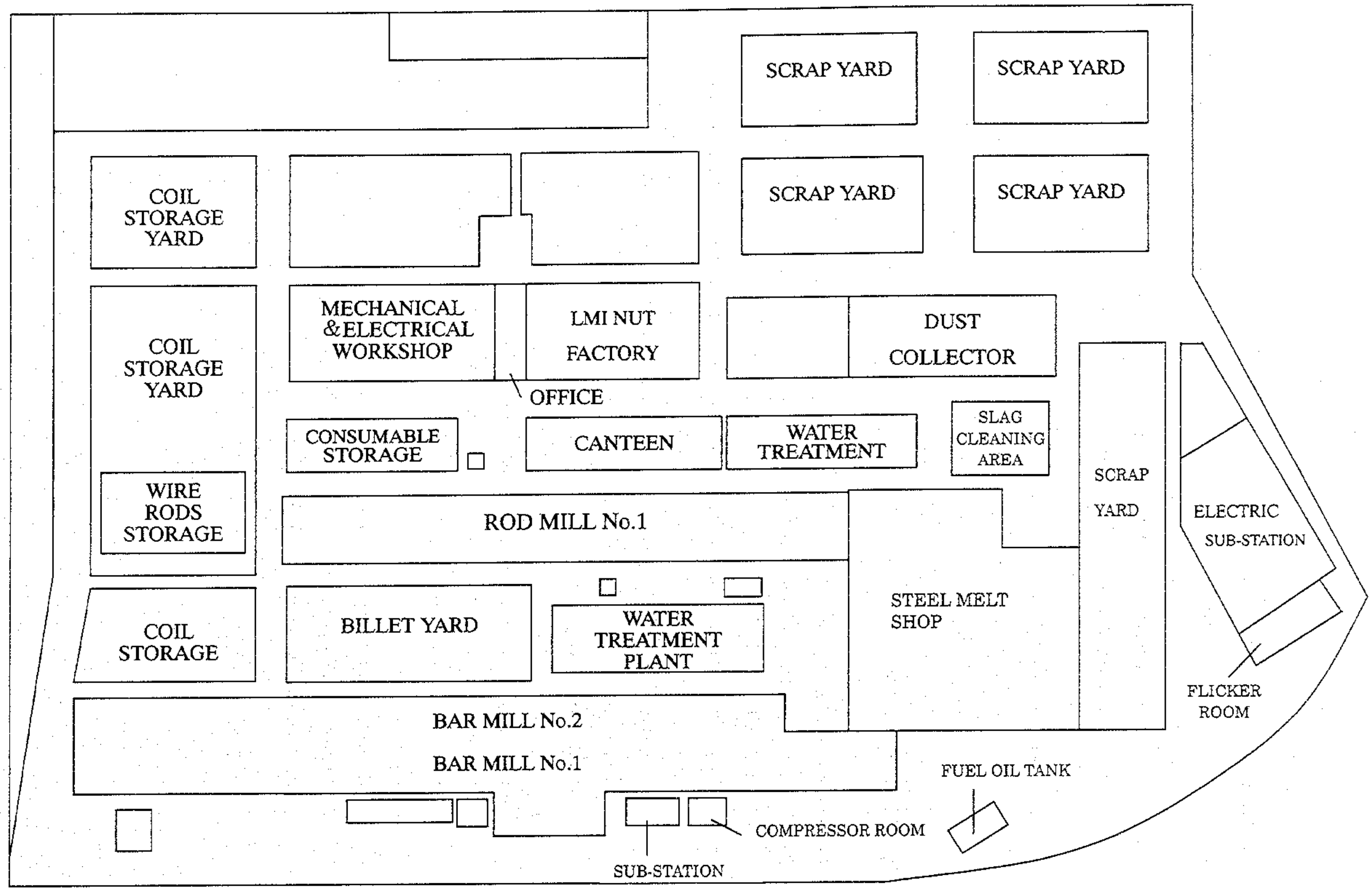


Figure 12-1 Layout of Steel Works

(7) Auxiliary Facilities

In addition to the above major facilities, the steel works have the following auxiliary facilities

1) Open scrap yard
2) Shredder plant
3) Dust collector
4) Water treatment plant,
5) Compressor room
6) Electrical sub station,
7) Lubricant storage yard,
8) Mechanical and electrical work shop
9) Coil storage yard

(8) Flow Sheet of Products

Process flow diagram is shown in Figure 12-2.

(9) Electric Power Receiving

1)	Receiving voltage	: 132 kV
2)	Maximum demand	: 65 MW
3)	Power factor	: 98 %

(10) Unit Price of Energy

1)	Fuel oil (MFO)	: 0.35 RM/l		
2)	Diesel oil	: 0.65 RM/l		
3)	Unit price of electricity	: Demand charge		16.20 RM/kW·month
		Power rates…	on peak	0.178 RM/kWh
			off peak	0.098 RM/kWh

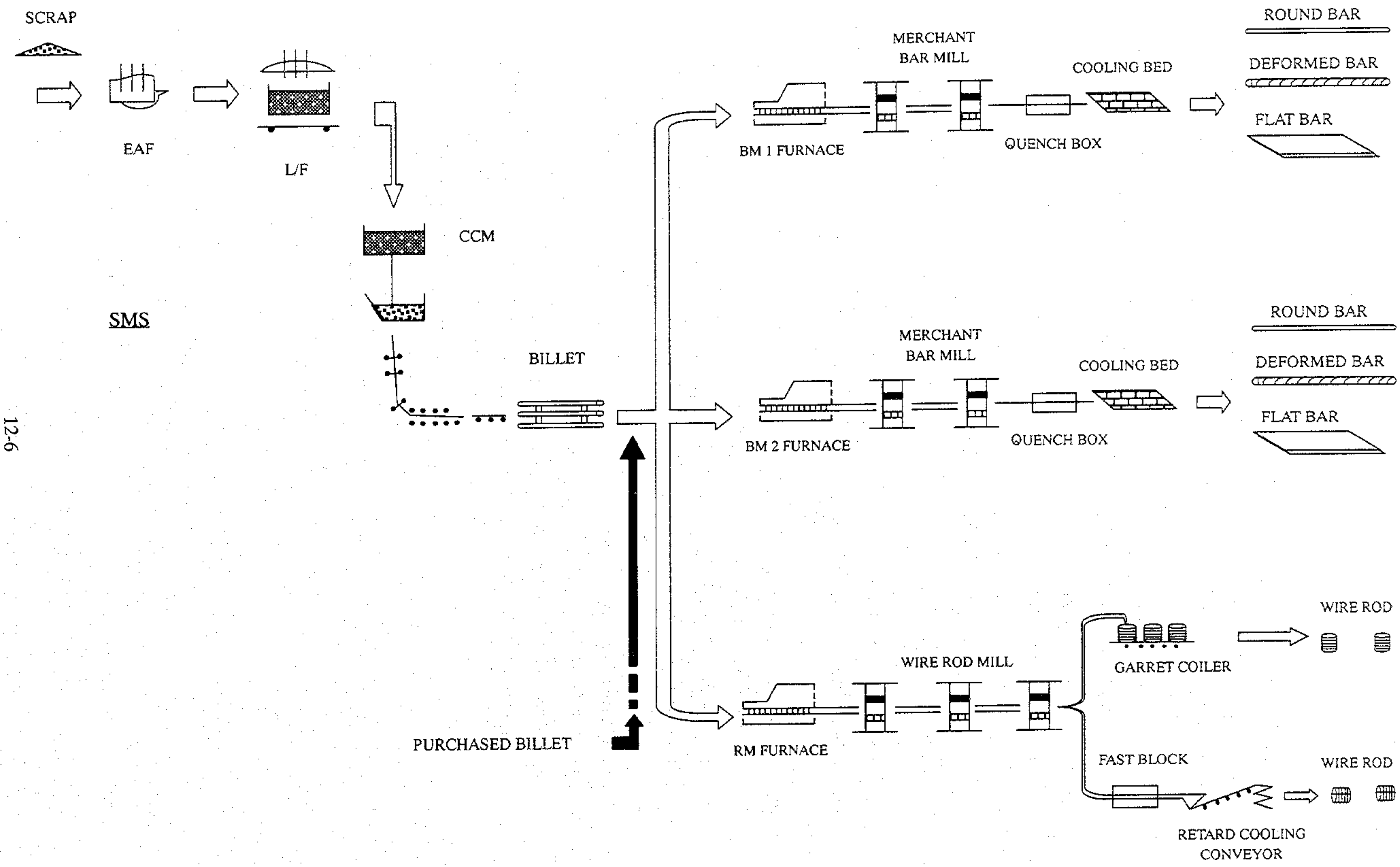


Figure 12-2 Process Flow Diagram

12-3 Trends in Energy Consumption and Unit Consumption

(1) Unit Consumption of Steel Making Plant

Unit consumption of the steel making plant is shown in Table 12-2.

The table indicates good operation results of electric power consumption from 400 to 440 kWh/ton (Billet), and oxygen consumption from 34 to 40 Nm3/ton in EAF.

(2) Material Balance Sheet

The material balance sheet for 1996 is shown in Figure 12-3.

(3) Unit Consumption of Rolling Mill Plant

Monthly operation parameters including unit consumption of Rod Mill 1 are shown in Table 12-3. The table shows low oil consumption from 28 to 30 liters per ton.

Table 12-4 shows unit consumption of Bar Mill 2.

Table 12-2 Monthly Operating Parameters for EAF - Steel-Making Plant -

This table cannot be made public becausc of ASM's confidentiality.

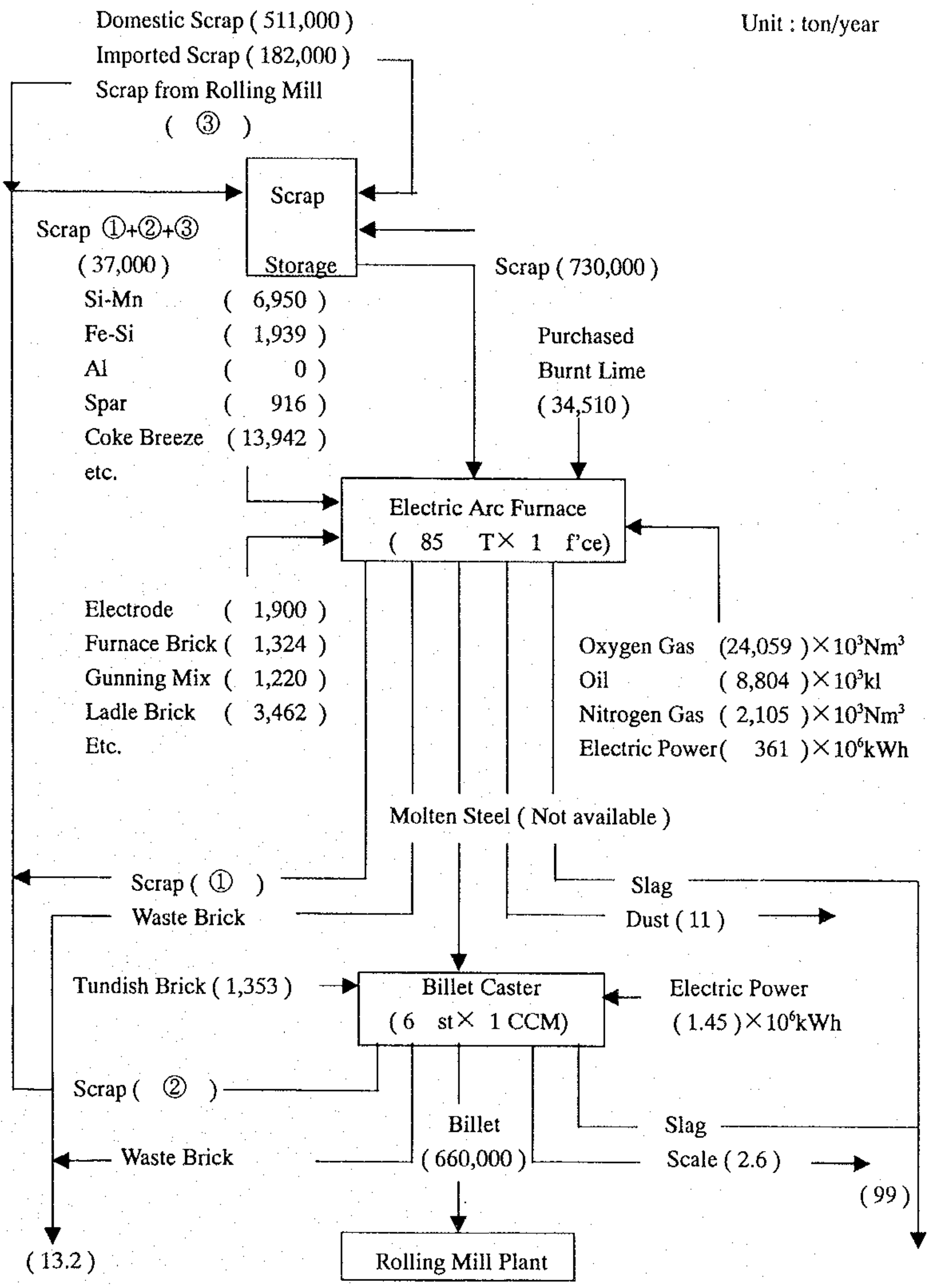


Figure 12-3 Material Balance in 1996

Table 12-3 Unit Consumption of Utilities for Recent 12-Month Period - Rod Mill 1-

Table 12-4 Unit Consumption of Utilities for Recent 12-Month Period - Bar Mill 2-

These tables cannot be made public because of ASM's confidentiality.

12-4 Current Condition and Problems with Energy

12-4-1 Energy Management and Efficiency

Consumption of electric power, oxygen gas and fuel oil, all representing different types of energy, are measured by instruments installed in the control pulpit, and daily, weekly, monthly and annual reports are prepared for management review together with other operation parameters by computer processing. Daily operation results are reported and discussed in the morning meeting every day.

12-4-2 Results for Rationalization of Energy Use

The following measures for energy saving are taken.

1. Use of large capacity transformer for EAF
2. Application of high power and long arc operation to the EAF, resulting in reduced melting time, or short tap-to-tap time.
3. Use of oxy-fuel burners in the EAF makes it possible to reduce melting time and ensures uniform temperature distribution, or elimination of cold spots.
4. Foamy slag operation is applied to the EAF to use the arc heat more efficiently and to prevent the damage of the furnace wall by enveloping the arcs.
5. The eccentric bottom tapping (EBT) system (slag-free tapping) of the EAF results in shorter tapping time and heat loss.
6. The ladle furnace (LF) contributes to increased production of steel by relieving the EAF of the refining load. The EAF is operated for the sole purpose of melting scrap and the LF for refining the heat.
7. Adoption of a low impedance electrode supporting arm increases electric power efficiency.
8. Ca-Si injection for high quality steel contributes to maintaining stable operation.
9. Slit rolling contributes to increased production and energy saving.
10. Adoption of recuperators in the rolling mill utilizes the waste heat of the reheating furnace for preheating combustion air and fuel oil

ASM has been improving productivity by expanding the capacities of the relevant equipment pieces and by adopting state-of-the-art technologies. Tap-to-tap time has been improved to between 54 and 66 minutes.

Consequently, electric power consumption has also been reduced to 420 kWh per ton.

12-5 Current Condition and Problems with Facilities

12-5-1 Identification of Current Problems

(1) Problem with Major Energy-Consuming Facilities

As Section 12-4-2 describes, ASM has also been improving productivity and energy saving by expanding capacities and introducing state-of-the art technologies. ASM has achieved superb operation results, but some further improvements are expected on the following items.

1. Electric power consumption of the electric arc furnace
   There is some room to further reduce electric power consumption by improving operating methods.
2. Introduction of a regenerative burner to the reheating furnace
   Reduction of fuel oil consumption by improving the heat recovery efficiency.
3. Hot charge
   Reduction of fuel oil consumption by application of hot charge.
4. Veneering of the furnace wall with ceramic fiber blanket
   Saving of fuel consumption by reduction of radiation heat from the furnace wall.
5. Reduction of dispersion for extracting temperature
   Saving of fuel consumption by improving the operating method.
6. Improving the air fuel ratio
   Reduction of the air fuel ratio by restoration of the oxygen content meter.

(2) Problems in Energy Consumption Already Recognized, and Items Requested for Auditing

1. ASM has envisaged reduction of electric power consumption for the electric arc furnace from 420 kWh/ton to 350 kWh/ton.
2. ASM has also envisaged reduction of electricity consumption for the ladle furnace and shredding plant.
3. ASM has requested the following items for energy audit.
   a. Voltage fluctuation in the EAF and LF.
   b. The cause of high power factor in the EAF and LF.
   c. High loss from substation to EAF and LF.

(3) Major Items and Points of Factory Audit

The JICA study team has concluded for the following reasons that the major items and points are heat balance of the reheating furnace and the electricity measurement.

1. As sub section 12-4-2 mentions, many measures have already been introduced to the electric arc furnace for saving energy consumption.
2. The scrap preheater is effective for energy saving, but recently, this is not recommended because of the hazardous dioxin generation problem. Therefore, it is difficult to save energy in the EAF by a substantial improvement of equipment.
3. The product mixture of ASM is not simple.
4. There is scope to the reheat furnace for energy saving.
5. The problems proposed by ASM are almost all electricity-related.

12-6 Method of Energy Audit

Energy consumption auditing work is based on analysis of monthly operation records and actual plant measurement or observation, which involves confirming operation data and collecting necessary data. The monthly operation record was collected through interviews, and actual plant measurements were performed according to the description in section 12-6.

12-6-1 General Description of Energy Audit

In order to select an energy auditing facility, monthly operation data was collected through March/'98 and June/'98 interviews.

Through the preliminary interview study, selection of a plant auditing facility was agreed upon, and the preheating furnace in the rod rolling mill was selected for the energy audit facility.

The main reasons for rejecting the electric arc furnace for the energy audit are as follows:

(1) As mentioned above, ASM steel making shop has already introduced the most modern equipment.

(2) One of the measuring targets for the electric arc furnace is high temperature (over 1000℃) corrosive exhaust gas, and frequent thermo-couple change is essential. Also, the measuring period of the electric arc furnace is not less than 3 continuous heats, and data collecting man-power is not less than 6 experts of metallurgical measuring experience. Nevertheless, combustion heat generated in the furnace is still a matter of discussion (whether heat generation is in the bath, in the furnace or combustion chamber).

At the same time, the preheating furnace of the rod mill is located side by side with the continuous caster delivery table, allowing adoption of hot billet charging. Application of hot billet charging enables maximum energy saving of over 30%.

As a conclusion, measurement of the rod mill reheating furnace is analyzed for energy audit, and observation of electric arc furnace operation and monthly operating data are summarized for discussion.

12-6-2 Outline of Measuring Items, Points and Measuring Instruments

The reheating furnace of the rod rolling mill, which is planned for energy audit, and electric power supply, which was requested by ASM members, were measured in respect to the following items.
In general, where there is mill data, data is collected through the mill instruments, and other data is measured by JICA members.

(1) Reheating Furnace: Measuring Items, Points and Measuring Instruments
Reheating furnace measuring items and points are illustrated in Figure 12-4.
The measuring period is 1st , 4th and 5th shift after weekly shutdown.

(2) Electricity: Measuring Items, Points and Measuring Instruments

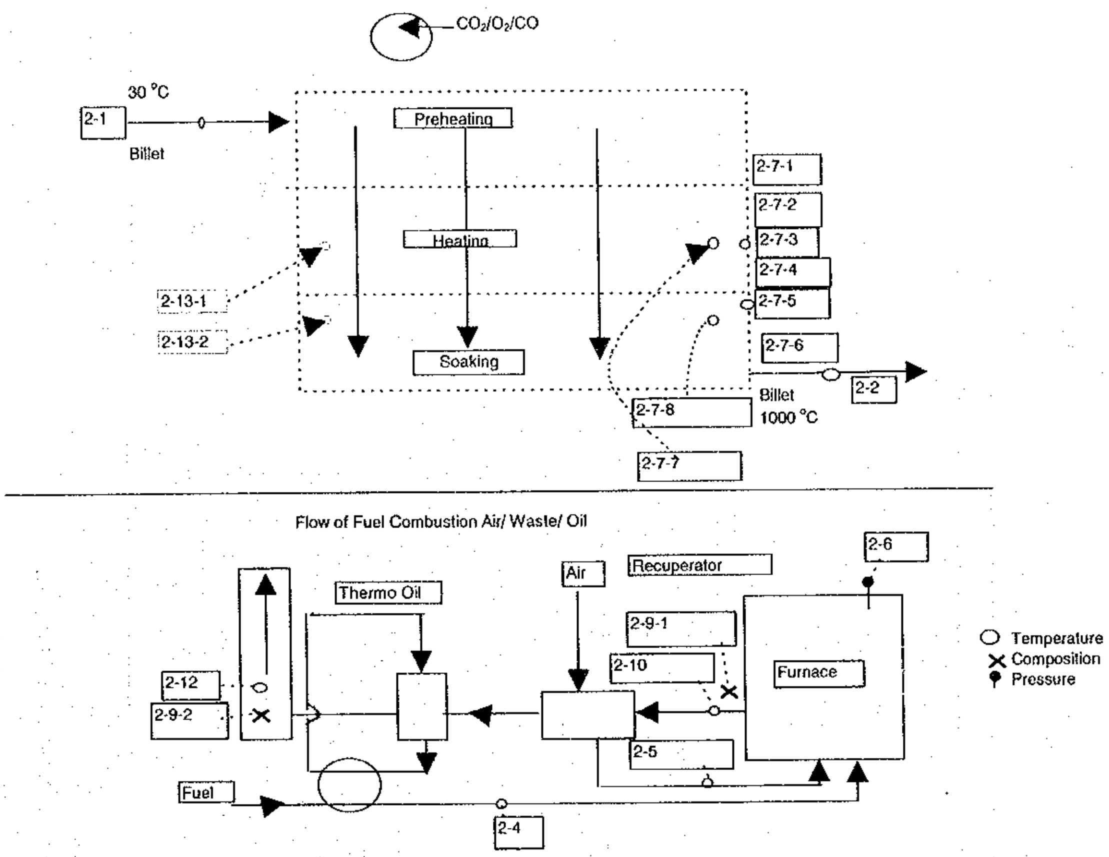
1) Measuring Items

1. Electricity.
2. Voltage.
3. Electrical current.
4. Power factor.

2) Measuring Points
Measuring points are shown in Figure 12-5.

Details of measuring items, points and measuring equipment are shown in Table 12-5.

REHEATING FURNACE: TEMPERATURE MEASUREING POINTS



Measurements

Temperature	2-1	Billet Charging Temp
	2-2	Billet Extracting Temp
	2-4	Fuel Supply Temp
	2-5	Combustion Air Temp
	2-7-	1 - 6 Furnace Wall Temp
	2-7-7	Furnace Soaking Zone Roof Temp
	2-7-8	Furnace Preheating Zone Roof Temp
	2-10	Exhaust Gas Temp
	2-12	Outlet of Recuperator Temp
$O_2/CO_2/CO$	2-9-1	Exhaust Gas
	2-9-2	Outlet of Recuperator
Outside condition	2-16	Temp/Humidity/Pressure

Record

Product	2-3	Billet Heating Quantity (T/hrs)
Temperature	2-4	Fuel Supply Temp
	2-5	Combustion Air Temp
	2-10	Exhaust Gas Temp
	2-12	Outlet of Recuperator Temp
	2-13-1	F'ce Heating Zone Atmosphere
	2-13-2	F'ce Soaking Zone Atmosphere
Pressure	2-6	Furnace Pressure

Figure 12-4 Measuring Items and Points

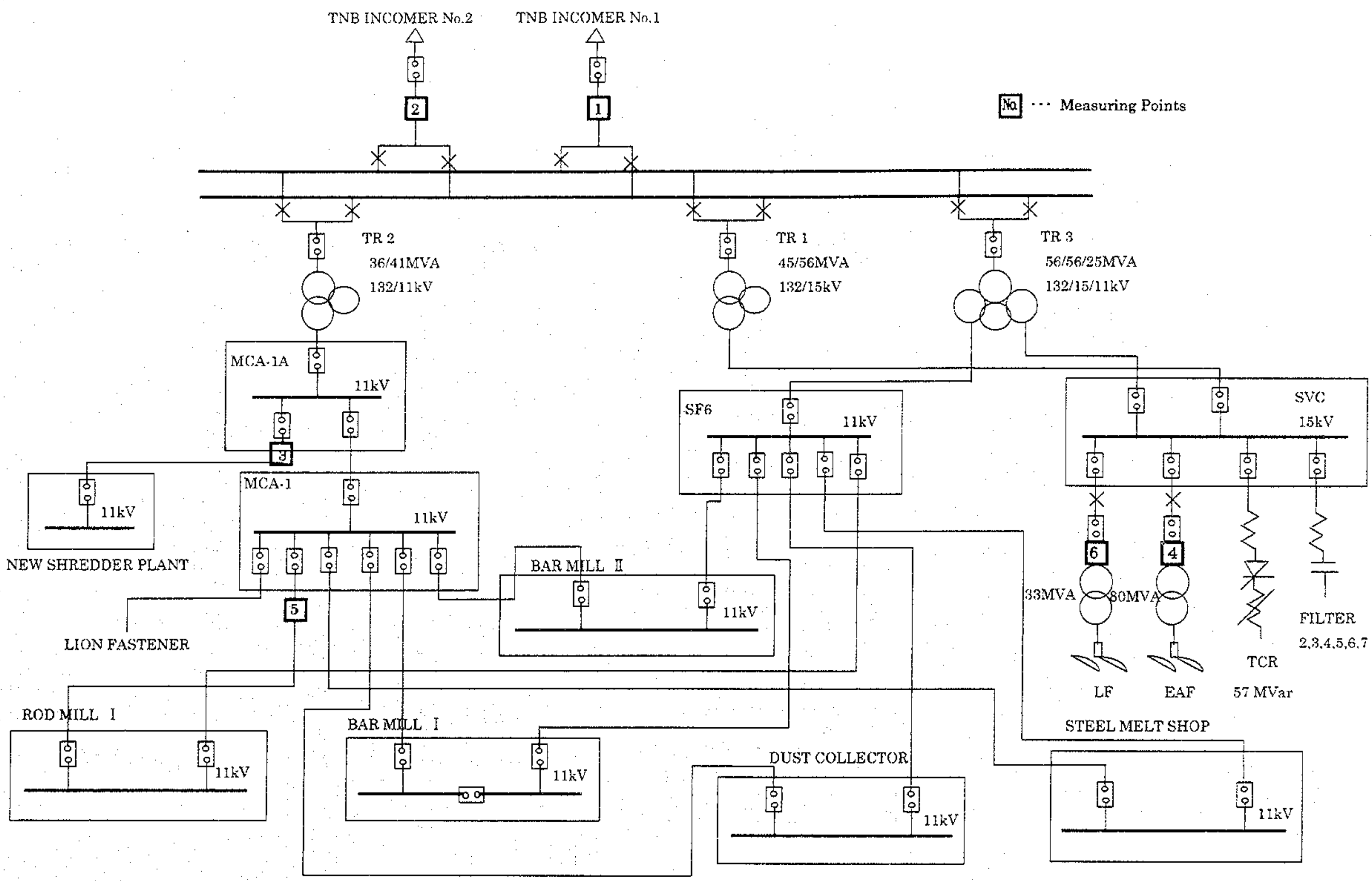


Figure 12 -5 Single Line Diagram

Table 12-5 Outline of Measurements for Energy Audit (ASM)

Major Items of Energy Audit & Subject Items and Points	Measurement or Estimate	Available Equipment for Measurement			
		Required Equipment	ASM	JICA	Local Labo.
1.Electrical Power Receiving & Distribution					
1) Voltage	M	Clamp on Power Hitester		x	
2) Electrical Current	M	ditto		x	
3) Electricity	M	ditto		x	
4) Power Factor	M	ditto		x	
2. Measurement around the Reheating Furnace					
(1) Billet					
1) Charging Amount	M	Weigher or Ope. Record	x		
2) Charging Temperature	M	Radiant Pyrometer(Low)		x	
3) Extracting Temperature	M	Radiant Pyrometer(High)		x	
4) Extracting Amount	M	Weigher or Ope. Record	x		
5) Heating Time	M	Clock	x		
6) Scale Loss	M	Weigher or Ope. Record	x		
(2) Fuel Oil					
1) Flow Rate	M	Operation record & Data	x		
2) Composition (C, H, N, O, S, Moisture)	M	C, H, N Analyzer etc.			x
3) Heating Value	Review	Supplier's data sheet	x		
4) Supply Temperature	M	Operation record & Data	x		
5) Flow Rate of Each Zone	M	ditto	x		
(3) Combustion Air					
1) Temperature	M	Operation record & Data	x		
2) Flow Rate of Each Zone	M	ditto	x		
3) Air-fuel Ratio of Each Zone	M	ditto	x		
(4) Reheating Furnace					
1) Temperature of Each Zone	M	Operation record & Data	x		
2) Furnace Pressure	M	ditto	x		
3) Wall Temperature	M	Thermoelectric Pyrometer:K		x	
(5) Combustion Exhaust Gas					
1) Temperature	M	Operation record & Data	x		
2) Composition of Exhaust	M	CO, CO2 Content meter		x	
Gas (CO, CO_2, O_2)		Oxygen Content meter		x	
3) Inlet Temp. of Recuperator	M	Operation record & Data	x		
4) Outlet Temp. of Recuperator	M	ditto	x		
(6) Outside Air Temperature	M	Temperature Humidity Pressure Recorder		x	
(7) Humidity	M			x	

12-7 Results of Measurement

12-7-1 Results of Measurement and Heat Balance of Reheating Furnace

(1) Result of Measurement

Table 12-7 shows the results of measurement together with related operating data.

Compared with nominal heating capacity, actual productivity is low, at 1/3 to 1/4 of the nominal capacity.

Considering the effect of shut-down, measured data are divided into 3 typical conditions: 1st shift, when heat output includes heating up the furnace; 4th shift, when wall temperature is extraordinarily high; and 5th shift, when wall temperature becomes low.

(2) Heat Balance of Reheating Furnace

Based on measured data, 3 heat balance sheets are calculated. Table 12-8 shows the summary.

Table 12-6 Results of Reheating Furnace Measurement

Measurement	Item		No.	08/10/98					09/10/98				
			DATE / TIME	10:00	12:00	14:30	16:00		10:00	12:00	15:00	16:00	
FURNACE	TEMPERATURE	℃	2-1					30	30	31	33	33	
			2-2					1,030	1,039	1,050	1,078	1,097	
			2-4				93	97	102	96	96	95	
			2-5				293	237	300	256	296	310	
			2-7-1	76	78	83	85		101	90	88	87	
			2-7-2	96	104	111	116		132	102	100	100	
			2-7-3	106	112	122	127		160	115	115	116	
			2-7-4	85	89	93	96		121	95	95	95	
			2-7-5	124	132	142	149		182	130	130	130	
			2-7-6	119	131	144	149		179	130	135	135	
			2-7-7	127	134	145	158		173	100	101	107	
			2-7-8	152	170	187	195		206	138	138	140	
			2-10				542		548	555	617	618	
			2-12				220		240	215	242	229	
			2-13-1					760		834	961	942	
			2-13-2					1,060		1,080	1,135	1,157	
	PRESSUR	mm water	2-6					0.36	0.3	0.38	0.78	0.73	
	$O_2/CO_2/CO$	%/%/ppm	2-9-1			11.6/ 6.8/ 1	4.4/ 12.3/ 2		4.4/ 12.3/ 2				
			2-9-2			17.6/ 2.5/ 0	15/ 4.4/ 0		15/ 4.4/ 0				
	Billet Quantity	T/hr	2-3					30	30.3				
	Fuel Used	kg/hr		20.16					870				
		kg/T		891					28.7				
OUTSIDE CONDITION	Temp	℃	2-16	44.2					29	31	33	32	
	Humidity	%							70	59	54	56	
	Pressure	mm Hg							760				

(3) General Evaluation of the Measured Data

Among the 3 measured data, the 5th shift data is understood as typical of ASM conditions, when the wall temperature reached stable condition.

The stable condition shows the following features;

1. The unit fuel consumption is 28.7 kg/t (272.9 x 10^3 kcal/t), which is a sound value. This value is lower than the Japan's target value in 1996, 275 x 10^3 kcal/t, by NEDO (New Energy and Industrial Technology Development Organization). ASM has actually sustained superb operation.
2. Air/fuel ratio is 1.25, which is excellent for a steel reheating furnace.

3. Furnace pressure is 0.3-0.8 mm H_2O, which is a sound value. At the charging opening and discharging opening on the furnace side, a very small amount of positive pressure is confirmed.
4. Heat recovery efficiency of the recuperator is 41%, which shows effective functioning.
5. Waste gas temperature at the recuperator inlet point is 618℃, which suggests the effect of a high-efficiency recuperator is small.
6. Combustion air leakage ratio in the recuperator is estimated at 21% of the total blast, which is not such a large amount.
7. The temperature variation of extracted material shows 60℃, which suggests the possibility of energy adopting the lowest temperature.
8. The temperature of charged material, which was 300℃ in the hearing data, was ambient temperature at the time of measurement.
9. Furnace wall temperature varies from start-up after weekly shutdown, the highest record being 206℃ (roof, at 4th shift), and drops to 139℃ in the 5th shift, which is still high.

   The low fuel consumption value considerably accords with the Japanese experience, which the fuel consumption is minimized at around 300 kg/hr·m^2 of heating load per hearth (for nominal capacity of ASM, 60,000 / (17.2 x 12.5) = 270 kg/hr·m^2, at actual operation, 150kg/hr·m^2)

Table 12-7 Summary of Heat Balance Calculation

Shift			1st Shift	4th Shift	5th Shift
Productivity		t/hr	20.2	30.3	30.3
Total Energy Consumption		10^3kcal/t	500.3	319.9	319.7
Input	Combustion Heat of Fuel	%	84.8	85.3	85.3
	Sensible Heat of Fuel	%	0.2	0.3	0.3
	Sensible Heat of Combustion Air	%	12.3	10.2	10.2
	Heat Content of Charged Steel	%	0	0	0
	Heat of Formation of Slag	%	2.7	4.2	4.2
Output	Heat Content of extracted Steel	%	32.5	51.4	53.7
	Sensible Heat of Scale	%	0.6	0.9	0.9
	Sensible Heat of Waste Gas	%	33.6	22.0	24.8
	Heat Loss from Furnace Body	%	4.9	6.2	6.0
	Other Heat Loss	%	28.4	19.5	14.6
Remarks	Waste Gas Temperature (Rec. Inlet)	℃	542	548	618
	Roof Temperature (Soaking Zone)	℃	175	206	139
	O2/CO2 Content (Rec. Inlet)	%/%	11.6/6.8	4.4/12.3	4.4/12.3
	Air/Fuel Ratio	-	2.15	1.25	1.25

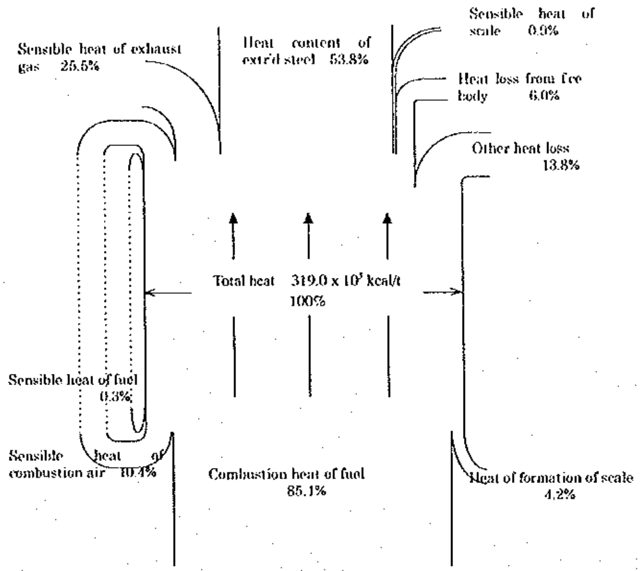


Figure 12-6 Heat Balance of 5th Shift

12-7-2 Electricity

(1) Single Line Diagram

Figure 12-5 shows a single line diagram of the ASM. There are two 132kV incoming lines from TNB. There are three main transformers. Their capacities are 45/56 MVA , 36/41 MVA and 56/56/25 MVA , and their secondary voltages are 15kV for EAF and LF, and 11kV for other plants.

The measuring points are shown by the numbers from 1 to 6 in Figure 12-5.

At the 15kV Bus-bar for EAF, there are automatic reactive power compensators and harmonic filters.

(2) Electricity Consumption Measured at Power Receiving

Trend data of the electricity consumption measured at Incomer 1 is shown in Table 12-8. The total electricity consumption on October 10 was 1,440 MWh/d. The electricity consumption during the Peak Period based on the TNB tariff system was 815 MWh/d and the Off Peak Period consumption was 625 MWh/d. The share of Off Peak consumption was 43.4 percent. This value is appropriate for the factory's 24-hour operation.

(Share of Off Peak consumption = Off Peak consumption / Total consumption $\times$ 100)

The maximum and minimum demand (30 minutes) were 78.24 MW and 41.5 MW, and the average was 59.99 MW.

The load factor was 76.7 percent. This value is good, but it is preferable to increase this by means of reducing the maximum demand.

(Load Factor = Average / Max. Demand × 100 = 59.99 / 78.24 × 100 = 76.7 %)

(3) Power Receiving Electricity Data

1) Voltage

The maximum voltage was 138.9 kV and minimum voltage was 132.2 kV. The voltage regulation was 5.1 percent. This shows that the voltage fluctuation is relatively small.

[Voltage Regulation = (Max. Voltage - Min. Voltage) / Min. Voltage × 100

= (138.9 - 132.2) / 132.2 × 100 = 5.1 %]

2) Electricity and Power Factor

The power factor ranged from 0.950 to 0.995, the average being 0.972. This figure shows that the power factor was low when electricity demand was high, but was high when electricity demand was low.

(4) EAF Data

1. Voltage ranged from 27.20 kV to 32.25 kV. The voltage regulation was 18.6 percent. This value is not so small, but it is not a problem. Because, as mentioned above, the voltage regulation at the receiving point is ±2.55 percent.
   [Voltage regulation = (32.25 - 27.20) / 27.20 × 100 = 18.6 %]
2. Maximum electricity demand was 56.8 MW and electricity consumption on October 10 was 872,404 kWh/d. The power factor during operation ranged from 0.763 to 0.902, the average being 0.818. This means that only a few power factors exceed 0.85. Therefore, it would be difficult to say that power factor is too high.
3. The total melting amount on October 10 was 2,197 tons. So unit electricity consumption was 397 kWh/t.

(5) LF Data

1. Maximum electricity demand was 12.3 MW and electricity consumption during measurement was 99,635 kWh. The power factor during operation ranged from 0.512 to 0.841, the average being 0.785.
2. The total melting amount was 2,056 tons, so unit electricity consumption was 48.5 kWh/t.

Table 12-8 Electricity Consumption for Incomer No.1 (Oct. 10)

DATE	TIME	Voltage [kV]				Current [A]				Effective Power	Frequen-cy	Power Factor
		V1	V2	V3	Ave.	I1	I2	I3	Ave.	[MWh/h]	[Hz]	
10/10	0:30	138.8	138.7	138.9	138.8	171.7	181.3	179.6	177.6	36.78	50.11	0.971
10/10	1:00	134.0	134.9	135.0	134.6	199.2	197.6	204.2	200.4	24.80	49.99	0.971
10/10	1:30	137.5	137.6	137.8	137.6	186.5	190.0	191.1	189.2	39.32	50.00	0.951
10/10	2:00	138.1	138.1	138.6	138.2	179.9	171.5	182.9	178.1	23.20	49.98	0.967
10/10	2:30	137.2	137.5	137.6	137.5	66.5	67.1	68.1	67.2	38.16	49.99	0.967
10/10	3:00	134.4	133.8	135.2	134.5	250.5	241.3	211.7	234.5	28.72	50.02	0.950
10/10	3:30	138.3	137.1	136.7	137.4	72.1	117.4	94.9	94.8	29.18	50.08	0.971
10/10	4:00	133.1	133.6	134.9	133.9	202.8	187.9	200.3	197.0	36.18	50.08	0.964
10/10	4:30	136.5	137.2	136.6	136.8	162.0	177.7	202.2	180.7	31.26	49.95	0.961
10/10	5:00	134.6	134.5	134.2	134.4	182.8	198.4	200.7	194.0	36.44	49.83	0.961
10/10	5:30	133.4	132.7	133.8	133.3	200.8	213.5	183.3	199.2	27.82	49.98	0.967
10/10	6:00	133.9	133.6	133.3	133.6	141.5	189.8	172.1	167.8	31.84	49.94	0.963
10/10	6:30	135.5	135.8	135.6	135.7	178.5	188.5	199.8	188.9	37.62	49.96	0.967
10/10	7:00	138.5	138.3	138.5	138.5	0.0	0.0	0.0	0.0	26.74	50.04	0.970
10/10	7:30	138.8	138.5	138.7	138.6	0.0	0.0	0.0	0.0	32.12	50.06	0.976
10/10	8:00	133.7	134.4	133.5	133.9	206.0	202.8	236.2	215.0	26.12	50.03	0.965
10/10	8:30	135.7	135.1	135.5	135.4	158.5	172.7	158.5	163.3	31.84	50.04	0.962
10/10	9:00	132.6	132.6	132.4	132.5	224.9	229.8	239.8	231.5	24.04	49.93	0.971
10/10	9:30	135.7	135.4	135.7	135.6	0.0	0.0	0.0	0.0	29.94	49.92	0.977
10/10	10:00	133.7	133.3	133.9	133.7	179.2	182.4	172.4	178.0	36.26	49.94	0.957
10/10	10:30	132.9	133.0	133.4	133.1	191.3	179.1	191.5	187.3	31.08	49.94	0.963
10/10	11:00	136.0	136.3	136.2	136.2	148.7	154.1	172.5	158.4	33.62	49.96	0.953
10/10	11:30	136.0	136.8	135.5	136.1	127.5	173.5	197.1	166.0	28.08	49.80	0.979
10/10	12:00	136.3	136.1	136.4	136.3	0.0	0.0	0.0	0.0	29.46	49.96	0.995
10/10	12:30	137.2	137.2	137.2	137.2	118.4	140.0	130.0	129.5	25.18	49.93	0.984
10/10	13:00	137.1	136.9	137.2	137.1	37.5	38.1	39.8	38.5	29.22	50.06	0.995
10/10	13:30	137.1	136.9	137.3	137.1	136.3	131.4	139.7	135.8	30.50	49.96	0.986
10/10	14:00	135.4	134.9	136.4	135.5	203.3	175.8	162.9	180.6	27.72	50.05	0.991
10/10	14:30	135.7	135.5	135.5	135.5	144.6	166.8	156.1	155.8	34.22	49.98	0.984
10/10	15:00	136.8	136.3	136.8	136.6	157.2	159.0	149.3	155.2	24.80	50.02	0.976
10/10	15:30	135.9	135.8	135.9	135.8	140.7	152.2	154.4	149.1	29.92	49.94	0.976
10/10	16:00	136.9	136.6	136.9	136.8	52.8	54.6	54.1	53.8	25.10	49.98	0.985
10/10	16:30	137.0	136.8	137.0	136.9	39.8	40.4	41.9	40.7	33.10	50.04	0.975
10/10	17:00	136.4	136.4	137.1	136.6	195.7	172.6	188.0	185.4	29.68	50.03	0.973
10/10	17:30	135.7	136.3	135.1	135.7	166.8	182.4	219.0	189.4	30.60	50.02	0.980
10/10	18:00	136.6	136.3	136.6	136.5	60.9	62.2	63.2	62.1	20.58	50.03	0.985
10/10	18:30	135.4	134.5	134.7	134.9	158.4	183.3	153.0	164.9	22.96	50.08	0.980
10/10	19:00	134.1	134.2	135.1	134.5	124.9	99.2	102.8	109.0	22.82	50.01	0.979
10/10	19:30	134.9	134.8	134.8	134.8	157.1	172.1	169.0	166.1	34.04	49.96	0.974
10/10	20:00	134.2	134.5	135.0	134.6	172.2	155.3	167.7	165.1	29.62	49.98	0.976
10/10	20:30	134.3	134.7	135.3	134.8	179.5	151.4	175.5	168.8	34.08	50.02	0.968
10/10	21:00	135.1	135.4	134.4	135.0	152.2	209.0	201.9	187.7	25.50	49.97	0.968
10/10	21:30	134.0	134.3	135.0	134.4	184.0	158.4	178.5	173.6	29.26	50.01	0.983
10/10	22:00	136.8	136.7	137.3	137.0	160.6	149.3	156.9	155.6	34.90	49.94	0.962
10/10	22:30	133.6	133.8	134.4	133.9	165.9	155.3	165.7	162.3	27.50	49.90	0.975
10/10	23:00	134.5	134.5	134.9	134.6	180.0	190.4	173.6	181.4	33.90	50.09	0.974
10/10	23:30	133.1	133.1	133.5	133.2	177.6	190.0	183.7	183.8	23.92	50.00	0.980
10/10	0:00	137.2	137.2	137.4	137.3	59.3	60.2	62.0	60.5	35.62	50.04	0.980

(6) New Shredder Plant Data

1. Maximum electricity demand was 4,234 kW. Electricity consumption during operation was 16,693 kWh. The power factor during operation ranged from 0.492 to 0.949, the average being 0.656.
2. The shredding amount was 390 ton, so unit electricity consumption was 42.8 kWh/t.
3. The cause of high unit consumption is low productivity (56 t/h = 390 t / 7 h). It is necessary to operate with high productivity, and doing so will reduce unit consumption to 35 kWh/t.
4. Electricity consumption during plant stoppage was about 35 kWh/h. This means a 204,400 kWh loss per year , so it is preferable to check and reduce this loss.
   (204,400 [kWh/year] = 35 [kWh/h] × 16 [h/day] × 365 [day/year])

(7) Rod Mill I Data

1. Voltage was relatively stable. Voltage ranged from 10.70 kV to 11.32 kV. The voltage regulation was 5.8 percent. This is almost same as the receiving point.
   [Voltage regulation = (11.32 - 10.70) / 10.70 × 100 = 5.8 %]
2. Electricity ranged from 2.70 MW to 4.93 MW and the power factor ranged from 0.593 to 1.000, the average being 0.762. It shows that the power factor was low when electricity demand was high, and was high when electricity demand was low.

(8) Power Factor at EAF and LF

As mentioned above, the average power factors in the EAF and LF on October 10 were 0.818 and 0.785.

Here we study improving the power factor.

1) Prerequisites

(a) Specification of electric cable

a) Sub station - EAF: 3×5×630 mmsq (0.0308 Ω/km), 200 m.

b) Sub station - LF: 3×2×240 mmsq (0.0739 Ω/km), 250 m.

(b) Electricity data on 10 October

a) Average electricity of EAF: 36.4 MW

b) Average electricity of LF: 4.2 MW

c) Average electrical current of EAF: 1,713 A(=36.4MW/√3 ×15kV×0.818)

d) Average electrical current of LF: 206 A(=4.2MW/√3 ×15kV×0.785)

2) Energy Saving Effect after Improving by 1 Percent

(a) Electrical current after improvement

a) EAF: 1,692 A(=36.4MW/$\sqrt{3}$ ×15kV×0.828)

b) LF: 203 A(=4.2MW/$\sqrt{3}$ ×15kV×0.795)

(b) Electricity consumption saving amount

a) EAF: $0.0308\Omega/km \times \{(1,713/5)^2-(1,692/5)^2\} \times 3 \times 5 \times 200\ m/1,000\ m = 264\ W$

$= 0.26\ kW$

b) LF: $0.0739\Omega/km \times \{(206/2)^2-(203/2)^2\} \times 3 \times 2 \times 250\ m/1,000\ m = 34\ W$

$= 0.03\ kW$

3) Conclusion

As mentioned above, the amount of electricity consumption saved by improving the power factor is very small. This means, it is difficult to reduce electric power loss by improving the power factor.

And electric power loss between sub station and EAF and LF is as follows

EAF: $0.0308\Omega/km \times (1,713/5)^2 \times 3 \times 5 \times 200\ m/1,000\ m = 10,845\ W \fallingdotseq 11\ kW$

LF: $0.0739\Omega/km \times (206/2)^2 \times 3 \times 2 \times 250\ m/1,000\ m = 1,176\ W \fallingdotseq 1.2\ kW$

This means electric power loss between sub station and EAF and LF is also very small.

12-7-3 Energy Saving in EAF Compared with Japanese Operation Data

By comparing ASM monthly records with similar shops in Japan, a 15-20 kWh/t (Billet) improvement in the electric power consumption of ASM is expected.

Measurement of the energy heat-balance in an operating electric arc furnace is sometimes recommended as a reasonable method of energy-saving audit.

However, since reasonably accurate measurements can be obtained from the plant's financial data-acquisition system, additional measurements were not performed on this occasion.

(1) Expected Value of Energy Saving in EAF

1) Expected Improvement

Table 12-9 shows the expected value of electric power consumption, billet yield and carbon addition, estimated by comparing data of ASM EAF monthly records and data of Japanese EAF monthly records, although such conditions as scrap are not clear. Table 12-9 suggests improving the oxygen lancing operation and carbon addition, maintaining the same level of the oxygen consumption, and provide the same steel yield and reducing electric power consumption.

Table 12-9 Expected Unit Consumption of EAF

		Unit	Present data	Improvement	Expected value	Effect
1	Electric power	kWh/t	415	-	400 or less	15 or more
2	Yield	%(Billet/charge)	91.0	-	0	
3	Oxygen	Nm^3/t	35	Standard		
4	Coke breeze	kg/t	Standard	Slight increase		
5	Oxygen lance	kg/t	N.A	Slight increase		
6	Hearth material	kg/t	N.A	Slight increase		

(2) **Procedure of Estimation**

1) Basis of Estimation

(a) Actual operation data is collected and after classifying those data, correlation is found. On that correlation, ASM data is plotted and estimated according to a standardized state. Standardizing is done under the following conditions;

1. Oxygen consumption correlation is found from actual data, and standardized at ASM consumption of 35 Nm3/t.
2. Considering the product mixture of ASM (low carbon=5%, medium carbon=35%, rebar grade=60%), ASM unit consumption is a combination of a commercial grade Japanese steel shop and a high grade Japanese steel shop.

3. In regard to scrap handling, ASM's import scrap is substantial at 20% and is difficult to classify, so indoor scrap yard handling is congested since tap-to-tap is short at 53 minutes and the indoor the scrap yard has shredding equipment. Therefore, setbacks in the melting procedure due to the scrap problem occur more frequently than in Japan.

(b) Japanese data is obtained from confidential monthly reports published by the Japanese Federation of Iron and Steel Makers.
The examining period was from July 1996 to June 1997, and a total of 240 monthly data is plotted.

(c) ASM data is plotted according to 12-monthly data from July 1996 to June 1997.

2) Classification of Japanese Steel Shops

(a) Studying product mixture and scrap mixture, 7 steel shops are classified as high grade steel shops, and 4 steel shops are classified as special scrap steel shops.

(b) The correlation between oxygen consumption and electric power consumption is shown in Figure 12-9. It shows that with the increase of unit oxygen consumption, unit electricity power consumption decreases. The ASM tendency, whereby electricity consumption increases with oxygen consumption, is abnormal. It may indicate some significant change of scrap characteristics, such that improved electric power consumption from 1996 to 1997 occurred as if oxide content decreased.

3) Expected Electric Power Saving

From Figure 12-7, the difference between ASM and Japanese data is 5-50kWh/t (Billet), according to the classified groups: high grade steel shop, special scrap steel shop and commercial grade steel shop. As an expected saving value, considering unintentional variation of conditions, an improvement of 15kWh/t (Billet) would be appropriate. (Table 12-10)

Table 12-10 Expected Value of Electric Power Consumption

Classification	Monthly data		Expected value	
	Oxygen consumption (Nm3/t)	Electric power consumption (kWh/t)	Expected value at O2=35Nm3/t (kWh/t)	Improvement (kWh/t)
ASM	34-40	405-443	415	Standard
High grade shop	22-38	335-428	375	40
Special scrap shop	17-68	340-528	410	5
Commercial grade shop	21-45	330-455	365	50

(3) Comments on Possibility of Improvement

1) After classifying Japanese steel shops, some shops were selected as resembling the operating conditions of ASM, and then the expected improvement values were estimated. ASM data, whereby yield and oxygen consumption are high but electric power consumption is not low, suggests that in the ASM furnace, heat transfer is not good. This defect would be overcome by an active boiling reaction in the furnace. This would require additional carbon, and would therefore increase heat generation in the furnace.

2) In order to transfer more effectively the combustion heat of carbon additives, the oxygen lance position should be well into the molten phase, and also influence the metal phase, so that boiling action is not localized only in the slag phase, where violent boiling suddenly occurs.

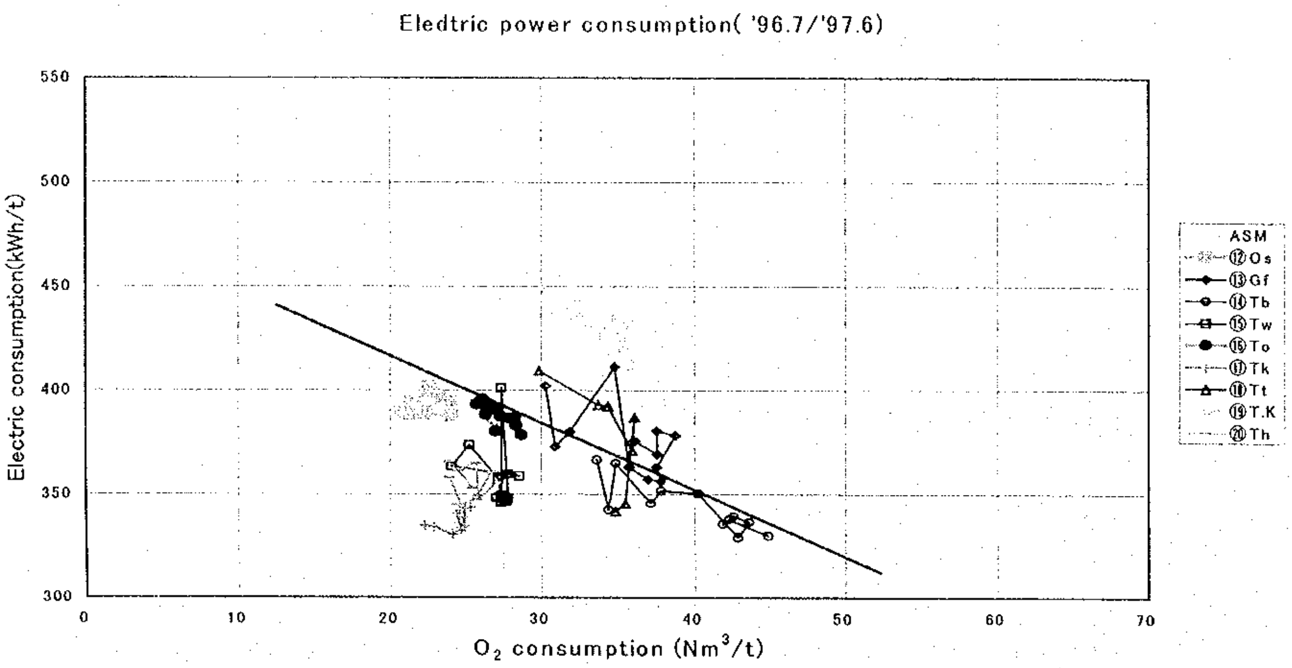


Figure 12-7-1 Oxygen Consumption and Electric Power Consumption (Commercial grade)

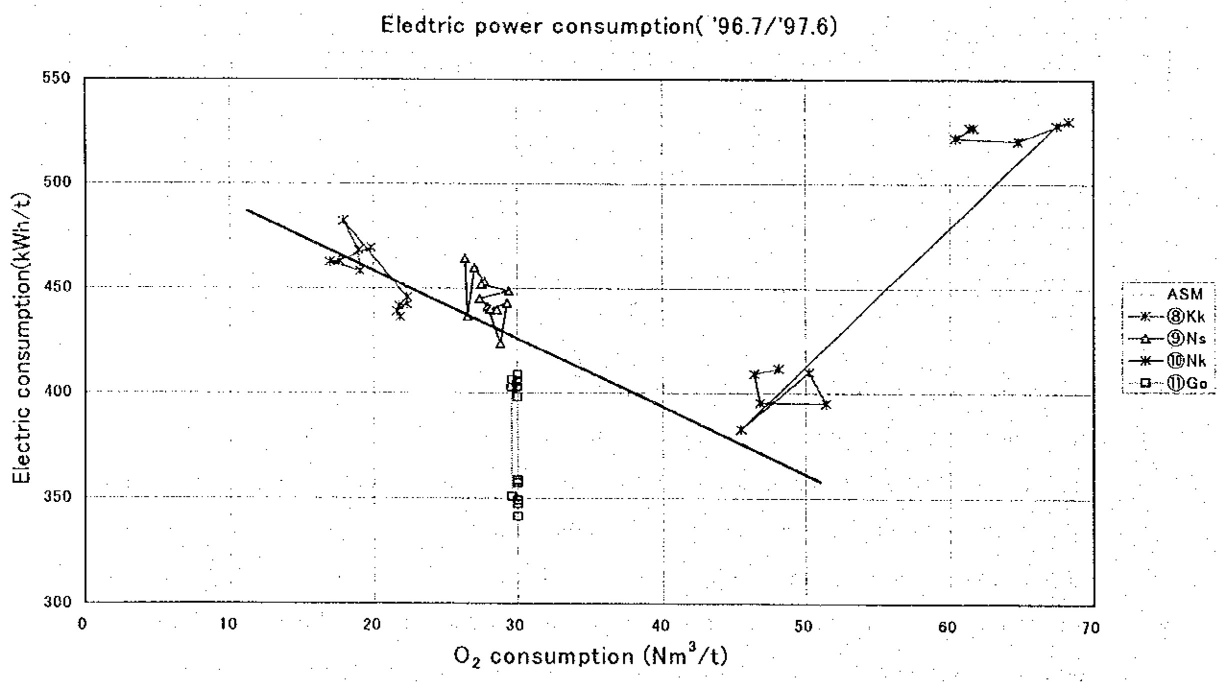


Figure 12-7-2 Oxygen Consumption and Electric Power Consumption (Special scrap)

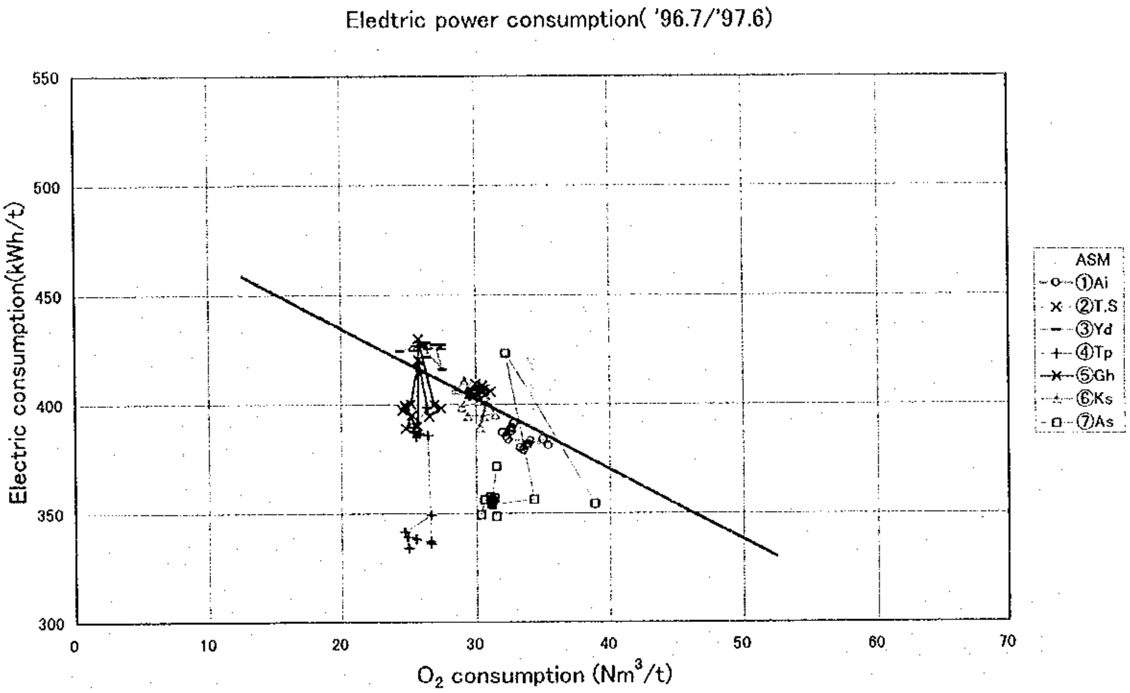


Figure 12-7-3 Oxygen Consumption and Electric Power Consumption (High grade steel)

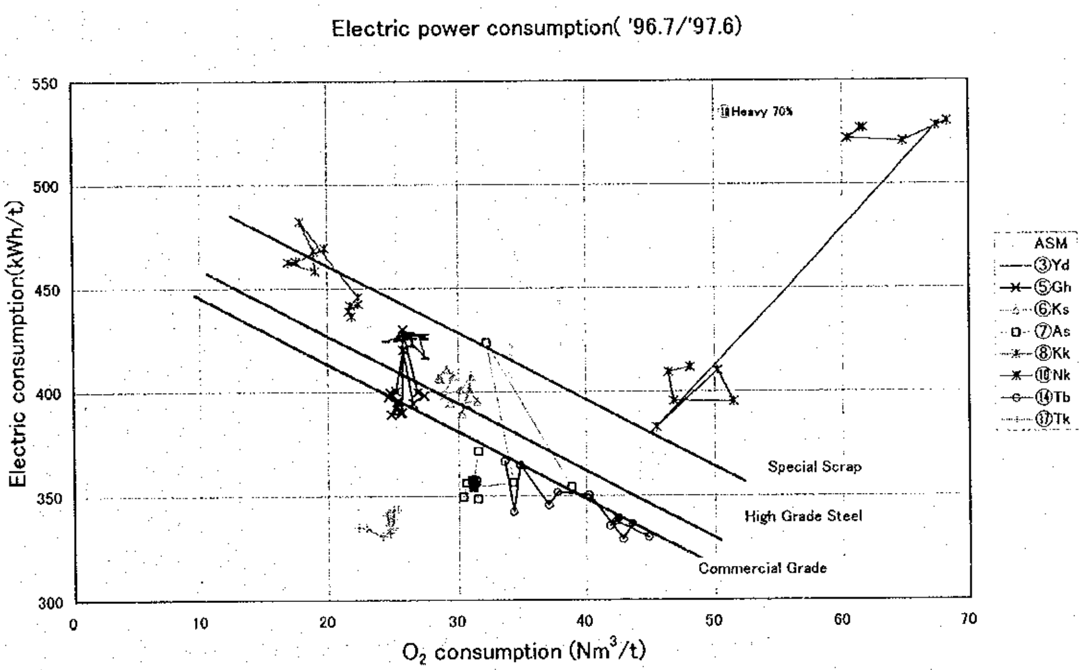


Figure 12-7-4 Oxygen Consumption and Electric Power Consumption (Summary)

12-8 Major Energy-Consuming Facilities and Energy Flowchart of Factory

(1) Major Energy-Consuming Facilities

The energy consumption for each facility is shown in Table 12-11. This shows that

1. 70 percent of the energy consumption is electricity and 22 percent is medium fuel oil.
2. The energy consumption of the EAF is 57 percent, and the LF 5.5 percent; CCM (include auxiliary facilities) is 7.7 percent and rolling mills is 30 percent.
3. 70 percent of the energy consumption and 80 percent of the electricity consumption are consumed in the steel making plant.
4. 76 percent of the medium fuel oil consumption is consumed in the reheating furnaces.

(2) Energy Flow

The primary energy flow is shown in Figure 12-8.

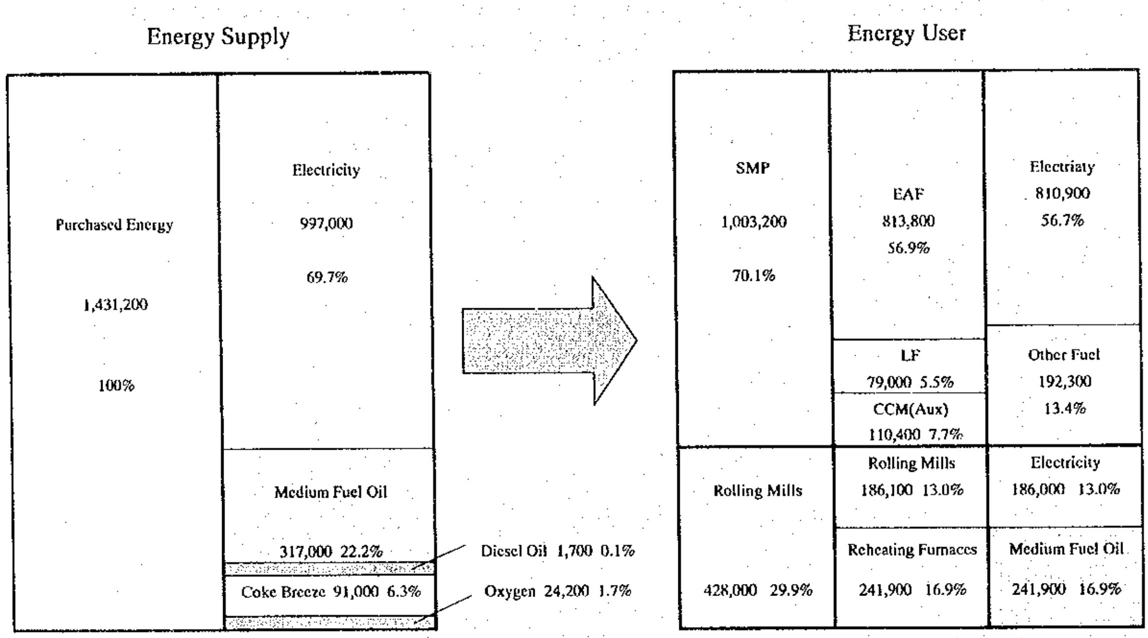


Figure 12-8 Primary Energy Flow Chart

Table 12-11 Energy Consumption of Each Facility

(1997)

Facility	Production	Electricity			Medium Fuel Oil			Diesel Oil		Oxygen		Coke breeze	Primary Energy	
	Amount	Unit	Consumption		Unit	Consumption		Unit	Consumption	Unit	Consumption	Consumption	Total	
	[10^3 t/y]	[kWh/t]	[MWh/y]	[%]	[kg/y]	[10^3 kg/y]	[%]	[kg/t]	[kg/y]	[Nm^3/t]	[10^3 Nm^3/y]	[t/y]	[10^6 kcal]	[%]
EAF	660	420	277,000	62	12	7,923	24	—	—	36	23,887	14,000	813,800	56.9
LF	660	53	35,100	8	—	—	—	—	—	—	—	—	79,000	5.5
CCM (Aux.)	660	73	48,300	11	—	—	—	0.25	165,000	—	—	—	110,400	7.7
Rolling Mills	790	105	82,700	19	32	25,440	76	—	—	—	—	—	428,000	29.9
Total			443,100	100		33,363	100		165,000		23,887	14,000	1,431,200	100
Primary Energy	[10^6kcal/y]		997,000 (69.7%)			317,300 (22.2%)			1,700 (0.1%)		24,200 (1.7%)	91,000 (6.3 %)	1,431,200 (100%)	

Comment:

1. Conversion factor of electricity to primary energy: 2,250 kcal/kWh
2. Low heating value of medium fuel oil: 9,509 kcal/kg
3. Low heating value of diesel oil: 10,300 kcal/kg
4. Conversion factor of oxygen to primary energy: 1,012.5 kcal/Nm3
5. Low heating value of coke breeze: 6,500 kcal/kg

12-9 Measures for Energy Efficiency Promotion

In accordance with the results of energy audit, measures to improve energy efficiency are described and discussed in this section. The major points are as follows.

1. Reduction of temperature variation of extracted material
2. Reduction of air/fuel ratio
3. Reduction of heat loss from furnace wall
4. Replacement of burner with regenerative burner system
5. Introduction of hot billet charging
6. Reduction of electricity consumption for new shredder plant
7. Reduction of electricity consumption for EAF

12-9-1 Reheating Furnace

Table 12-12 shows summary of improvement measures mentioned above.

As a summary of 12-8-1, estimation of effect on measures of reheating furnace is 3.57 kg-fuel/t (Billet), annually 1,350 t-fuel/year.

12-9-2 Reduction of Electricity Consumption for New Shredder Plant

As mentioned in sub section 12-6-2 (6), the reduction of electricity consumption during plant stoppage by checking the plant conditions may be able to reduce 35 kWh/h of electricity.
Therefore, 204,400 kWh/year of saving is expected by reducing electricity consumption loss.

(Saving amount = 35 kWh/h × 16 h/day × 365 day/year)

Saving the electricity consumption in the peak period: 178,850 kWh/y

Saving the electricity consumption in the off peak period: 25,550 kWh/y

Hardware is not necessary for this measure.

12-9-3 Reduction of Electricity Consumption for EAF

As mentioned in sub section 12-6-3 (3), it may be possible to reduce 15 kWh/t (Billet) of electricity consumption by active boiling reaction in the furnace and a deep oxygen lance position.
Therefore, 9,900,000 kWh/y of saving is expected by improving operating methods.

(Saving amount = 15 kWh/t(Billet) × 660,000 ton(Billet) /year)

Saving electricity consumption in the peak period: 5,775,000 kWh/y

Saving electricity consumption in the off-peak period: 4,125,000 kWh/y

Hardware is not necessary for this measure.

Table 12-12 Summary of Selected Measures for Reheating Furnace

S. No.	Item/Description	Measures and Cost	Fuel saving
1	Reduction of Temp. Variation of Extr'd Material Present / Improved R=60℃ / 30℃ Average = 1060℃ / 1045℃	Standardization of Operation Cost = 0	2,340kcal/t /(53.8/100) / 9,463 kcal/kgFuel = 0.46 kgFuel/t
2	Reduction of air/fuel ratio Present / Improved m = 1.25 / 1.15 O_2 = 4.4% / 3.0%	Oxygen Content Meter Cost = ¥5,400,000	28.7 - 28.2 = 0.5 kgFuel/t
3	Reduction of heat loss from furnace wall Present / Improved Heat loss 19060 kcal/t / 13500kcal/t	50mm Ceramics Fiber Blanket Veneering Cost = ¥9,000,000	(19,060 – 13,500) /(9,463 – 2,835 +1,158 + 29) = 0.71 kgFuel/t
4	Replacement of burner to regenerative burner system Assuming combustion air leakage (21%) & waste gas temp. (250℃), fuel saving is 3.3%.	HRS Burner System Cost = ¥237,500,000	28.7 - 27.7 = 1.0 kgFuel/t
5	Introduction of hot billet charging Assuming: Tonnage application ratio = 10% Mean charged temp. = 500℃ Energy contribution rate in increasing input heat content of billet = 80%.	Operation by Crane (installed) Cost = 0	60,000kcal/t x 0.8 / (53.8/100) / 9,463 kcal/kgFuel x 0.1 = 0.9 kgFuel/t

12-10 Benefits of Measures for Energy Efficiency Promotion

12-10-1 Energy Prices for ASM

(1) Fuel

The price of Medium Fuel Oil (MFO) is RM 317 per kl, being converted to RM 323.5 per ton by the assumed density.

(2) Electricity

The current price of electric power conforms to category E-3 (special rate for qualified customers) of TENAGA NASIONAL's tariff, effective from May 1, 1997, in the case of ASM. The following rates are applied, according to this category of tariff.

-Peak load rate (between 800 and 2200 hours):	0.178 RM/kWh
-Off-peak load rate (between 2200 and 800 hours):	0.098 RM/ kWh
-Maximum demand charge:	16.2 RM/kW/month

12-10-2 Benefits of Measures

The benefits of the measures are estimated and the results are summarized in Table 12-3.

Table 12-13 Estimation of Benefits from Measures

Measures	Benefit, RM/year
Reduction in Temperature Variation of Extracted Material	56,542
Reduction in Air/Fuel Ratio of Reheating Furnace	61,459
Reduction in Heat Loss from Reheating Furnace Wall	87,272
Replacement of Reheating Furnace Burner with Regenerative Burner System	122,918
Introduction of Hot Billet Charging	110,627
Reduction in Electricity Consumption for New Shredder Plant	34,339
Reduction in Electricity Consumption for EAF	1,432,200

12-11 Financial Evaluation of Measures

In this section, financial evaluations are made for the following measures requiring investment in order to ascertain the financial feasibility of the measures.

- Reduction in Air/Fuel Ratio of Reheating Furnace
- Reduction in Heat Loss from Reheating Furnace Wall
- Replacement of Reheating Furnace Burner with Regenerative Burner System

12-11-1 Premises for Financial Evaluation

Financial evaluations are made on the following premises.

1) Exchange rate: US$ 1 = RM 3.8 ; US$ 1 = JY 118
2) Project life: 15 years from the start of operation
3) Corporate tax rate: 28 percent
4) Depreciation: The straight-line method is applied. The depreciation rate is 5% per year for the plant and machinery.
5) Fixed investment: Table 12-14 summarizes the fixed investment cost for the measures, which were obtained by converting the Japanese Yen values in the previous section.

Table 12-14 Fixed Investment Cost for Measures

Measures	Fixed Investment Cost (RM)
Reduction in Air/Fuel Ratio of Reheating Furnace	173,898
Reduction in Heat Loss from Reheating Furnace Wall	289,831
Replacement of Reheating Furnace Burner with Regenerative Burner System	7,648,305

12-11-2 Results of Financial Evaluation

Table 12-15 shows FIRROI before tax, FIRROI after tax and the payback period for the measures.

Table 12-15 Results of Financial Evaluation

Measures	FIRROI before tax	FIRROI after tax	Payback Period
Reduction in Air/Fuel Ratio of Reheating Furnace	34.9%	26.0%	3.7 years
Reduction in Heat Loss from Reheating Furnace Wall	29.5%	21.9%	4.3 years
Replacement of Reheating Furnace Burner with Regenerative Burner System	-14.1%	-10.1%	n.a.

12-11-3 Conclusion of Financial Evaluation

According to the information obtained during the field survey, the lending rate in Malaysia has been ranging from 12 to 14% per annum recently. This rate could be regarded as an indication of the opportunity cost of capital in Malaysia.

For the first two measures, "Reduction in Air/Fuel Ratio of Reheating Furnace" and "Reduction in Heat Loss from Reheating Furnace Wall", favorable FIRROIs exceeding the above opportunity cost of capital, together with payback periods in the reasonable range were obtained. Accordingly, these measures can be regarded as financially feasible, under the conditions set for the study.

As for the third measure, "Replacement of Reheating Furnace Burner with Regenerative Burner System", FIRROI values are negative and the payback period exceeds 15 years, because of a relatively large investment cost and somewhat low benefits. This measure is considered financially unfeasible.

12-12 Recommendations for Energy Efficiency Promotion

Based on the energy audit and subsequent study for ASM including the financial evaluation, the following measures are recommended for improving its energy efficiency.

(1) Measures Requiring Investment

Among the three measures that require investment, the following two measures are recommended based on the financial evaluation.

(a) Reduction in Air/Fuel Ratio of Reheating Furnace in Rod Rolling Mill

During the energy audit, an air/fuel ratio of 1.25 was measured for the reheating furnace. It is recommended that the ratio be reduced to 1.15 of the optimum attainable value. Reduction in the air/fuel ratio results in a decrease in exhaust gas volume, which contributes toward energy saving in the reheating furnace. With this measure, an investment is required for installation of an oxygen content meter at the reheating furnace tail, replacing the broken one. This investment is financially feasible under the conditions of the study.

(b) Reduction of Heat Loss from Reheating Furnace Wall in Rod Rolling Mill

A reheating furnace wall temperature of over 130℃ was measured during the energy audit, although it is generally around 100℃ for ordinary furnaces. It is recommended that insulation be improved for reducing heat loss from the wall. The most convenient way of improving insulation is a veneering method, which involves overlaying a ceramic fiber blanket on the inside of the pre-build wall. The investment cost and benefit by fuel saving were estimated for this measure, assuming reasonable refractory heat conductivity and a blanket thickness of 50mm. This measure is regarded as financially feasible from the results of the financial evaluation, based on the investment cost and benefits.

(2) Measures Not Requiring Investment

Other recommended measures are mainly based on operational changes, requiring no investment.

(a) Reduction in Temperature Variation of Extracted Material in Rod Rolling Mill

It was found that the extracted billet temperature varied from 1,030℃ to 1,097℃, and the rolling procedure was performed successfully, even at the lowest temperature in the variation. It is recommended that the range of extracted billet temperature be reduced by half and the mean temperature be reduced to 1,045℃ by improved estimation of heating pattern changes. About a RM 57,000 annual fuel oil saving is expected by this measure.

(b) Introduction of Hot Billet Charging in Rod Rolling Mill

Hot billet charging to the reheating furnace is a popular energy-saving measure adopted by many steel mills. ASM has very favorable conditions to introduce hot billet charging. In fact, its rod mill reheating furnace is adjacent to the continuous caster delivery table and there is an overhead crane capable of transferring hot billets from the continuous caster delivery table to the reheating furnace charging table. It is recommended that hot billet charging be introduced in ASM. It is expected that 342 ton of medium fuel oil or RM 111,000 of the fuel bill will be saved annually by this measure, depending on the operation, especially the cooperation of the steel making shop and the rod rolling mill.

(c) Reduction in Electricity Consumption of New Shredder Plant

It was found during the energy audit that electricity was consumed at a rate of around 35 kWh/hour in the new shredder plant, even when the plant stopped. It is recommended that the cause of this loss be investigated and that the heat loss be prevented.

(d) Reduction in Electricity Consumption of Electric Arc Furnace (EAF)

The electricity consumption of ASM's EAF is somewhat higher than Japanese steel shops. ASM's data suggests that heat transfer in the EAF is rather poor according to analysis comparing data of Japanese shops. This problem would be solved by an active boiling reaction in the EAF, which would require additional carbon and would therefore increase heat generation. It is recommended that the oxygen lance position be well into the molten phase and also influence the metal phase, so that the boiling reaction is not localized only in the slag phase. About a 15 kWh/ ton electricity saving in the EAF is anticipated by this measure.

Chapter 13 Energy Efficiency Promotion Potential of Six Sub-sectors

In this chapter, energy efficiency promotion potential for the whole of Malaysia is estimated for the three commercial sub-sectors (hotels, shopping complexes, and hospitals) and the three industrial sub-sectors (cement, food, and iron/steel), assuming recommended measures in the study are diffused through out the country.

13-1 Methodology

Figure 13-1 illustrates the methodology for estimation of energy efficiency promotion potential.

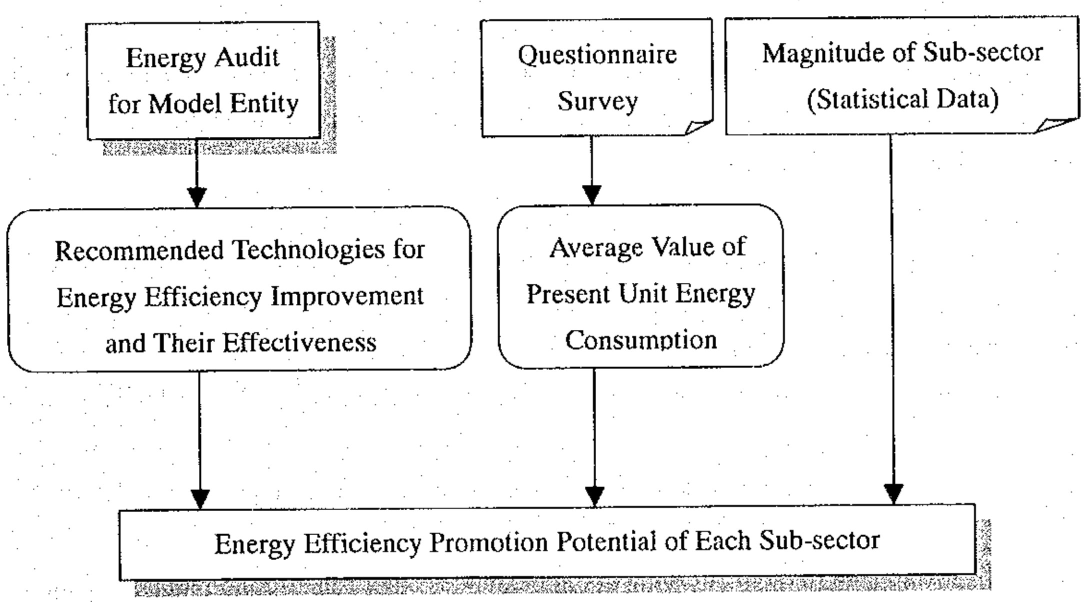


Figure 13-1 Methodology for Estimation of Energy Efficiency Promotion Potential

The first step in estimating the energy efficiency promotion potential for the whole of Malaysia is to carry out energy audits of the model entities selected for the six sub-sectors, in order to recommend measures based on the audits, and to estimate the effectiveness of the measures. The results of these investigations are presented in Chapters 7 through 12.

The second step is the questionnaire survey, which was conducted during July and August 1998 jointly by JBE&G and the study team to inquire about the individual entities in the commercial and industrial sectors. From the results of the questionnaire, the average value of unit energy consumption is obtained for each sub-sector.

The third step is to obtain data on the magnitude of sub-sectors from statistics.

Energy efficiency promotion potential is estimated based on the results of the first step, assuming the applicable range and current diffusion of measures in terms of energy-saving per total floor area in the commercial sector and per production volume in the industrial sector. The estimated potential per unit multiplied by the magnitude of each sub-sector obtained in the third step produces the absolute value of potential.

On the other hand, the current average value of unit energy consumption obtained in the second step multiplied by the magnitude of each sub-sector obtained in the third step produces the current energy consumption of each sub-sector. The calculated energy consumption is compared with the absolute value of potential.

It must be noted that the energy efficiency promotion potential estimated by this method is not larger than expected. The measures from which the potential is estimated are limited to measures recommended to the model entity. Because of this limited number of measures, the estimated potential is rather small. In some cases, selected measures may reflect features of the model entities. Bandar Utama Shopping Center, for which an energy audit was carried out as the model entity of shopping complexes, is a notable example. This shopping complex, newly established in 1995, has already applied some measures. Therefore, the effectiveness of such measures already applied to the model entity is not extended any further to the shopping complex sub-sector throughout Malaysia.

A database of energy efficiency, essential for estimation of potential by this method, has not been prepared in Malaysia. Efforts were made to supplement the data shortage as much as possible by means of the questionnaire survey and the statistical survey. However, detailed surveys of individual entities other than the six model entities are considered beyond the scope of the study and quite difficult to conduct due to the limited number of study team members and the study period. Therefore, data that requires detailed surveys, especially the current diffusion rate of the measures, is estimated by the study team.

It should be noted that the estimated potential is inevitably somewhat rough and small due to the aforesaid factors. It is desired that Malaysian authorities concerned with energy efficiency promotion develop potentials more accurately from the results of the study.

13-2 Energy Efficiency Promotion Potential in Hotel Sub-sector

The energy-saving potential by diffusion throughout Malaysia of the following measures that were recommended for Mingcourt Vista Hotel is estimated under assumptions set for each measure.

(1) Introduction of VVVF System into Lifts (Application of Inverters to Lifts)

This measure aims at energy efficiency promotion by changing non-inverter type lifts used in hotels to Variable Voltage Variable Frequency (VVVF) system lifts.

(2) Installation of Variable Air Volume (VAV) System in the Motors of Fresh Air Intake Blowers

Fresh air intake is provided to maintain a comfortable indoor atmosphere, however, excess volume of fresh air is observed in some cases. This measure is to install the VAV system in the motors of fresh air the intake blowers so that intake volume of fresh air can be controlled for the purpose of reducing electric power consumption of the blower.

(3) Increase Room Temperature by 2 Degree Centigrade

Almost all hotels are air-conditioned throughout the year in Malaysia to provide a comfortable space sheltered from hot weather. However, overcooling by excess air conditioning is observed in some cases. Under such circumstances, it is recommended that the set temperature be moderated, with the aim of reducing energy consumption in the chiller system under investigation.

Table 13-1 shows energy efficiency promotion potential assuming diffusion of recommended measures, and the percentage of the potential of total energy consumption. The potential totals 389.8 x 10^9 kcal/year in terms of primary energy, accounting for 4.9% of total energy consumption in the hotel sub-sector. The total potential is 173 GWh/year in terms of electric power and 38,980 TOE/year in terms of oil.

Table 13-1 Energy Efficiency Promotion Potential in Hotel Sub-sector

Measures	Potential	
	10^9 kcal/year	% of Total Energy Consumption
(1) Apply inverter control for lifts (introduce VVVF system into lifts)	79.8	1.0
(2) Introduce VAV system into motors of fresh air intake blowers	58.1	0.7
(3) Raise room temperature by 2 degrees centigrade	251.9	3.1
Total	389.8	4.9

13-3 Energy Efficiency Promotion Potential in Shopping Complex Sub-sector

The energy efficiency promotion potential by diffusion throughout Malaysia of the following measures that were recommended for Bandar Utama Shopping Center is estimated under assumptions set for each measure.

(1) Reduction of Illumination Intensity

Decreasing the illumination intensity of common areas highlights the interior of shops better. This measure is to save electricity used for lighting by decreasing illumination intensity.

(2) Increase Room Temperature by 2 Degrees Centigrade

Overcooling by excess air conditioning is observed in some shopping complexes in Malaysia. Under such circumstances, it is recommended that set temperature be moderated with the aim of reducing energy consumption in the chiller system.

(3) Prevention of Heat Loss from Entrances

This measure is to minimize the heat loss from entrances by replacing existing entrances with air-tight types such as rotating doors.

Table 13-2 shows the potential assuming diffusion of recommended measures, and the ratios of potential to total energy consumption. The potential is totally 135.7 x 10^9 kcal/year in terms of primary energy, accounting for 7.1% of total energy consumption in the shopping complex sub-sector. The total potential is 60.3 GWh/year in terms of electric power and 13,570 TOE/year in terms of oil.

Table 13-2 Energy Efficiency Promotion Potential of Shopping Complexes

Measures	Potential	
	10^9 kcal/year	% of Total Energy Consumption
(1) Decrease the illumination intensity	2.6	0.13
(2) Raise room temperature by 2 degrees centigrade	126.8	6.64
(3) Prevent heat loss from entrances	6.3	0.33
Total	135.7	7.10

13-4 Energy Efficiency Promotion Potential in Hospital Sub-sector

In Chapter 9 of the report, measures are recommended for Hospital Seremban based on an energy audit conducted of the hospital as the model entity. Quantitative benefits were obtained for two measures among those investigated in Chapter 9. However, the first measure, "Introduction of Inverter Control System for Lift Power Supply", was concluded as financially unfeasible, and the second measure, "Introduction of Latent Heat Storage System", aims at shifting the peak load to the off-peak period without reducing the total energy consumption. Accordingly, for the hospital sub-sector, energy efficiency promotion potential for the whole of Malaysia cannot be obtained from the results of the energy audit.

13-5 Energy Efficiency Promotion Potential in Cement Industry

The energy efficiency promotion potential by diffusion throughout Malaysia of the following measures that were recommended for APMC Rawang Works is estimated under assumptions set for each measure.

(1) Prevention of Air Leakage

This measure aims at power reduction by preventing air leakage from various locations in a plant.

(2) Rationalization of Transportation System

This measure aims at power reduction by changing the transportation system of coal shale and cement from a pneumatic system to a mechanical elevator and air slide system.

(3) Construction of Coal Drying/Grinding Mill

This measure aims at improving combustion efficiency by combustion of finer powder as well as changing the fuel type from fuel oil to coal to reduce energy cost.

(4) Change of Feeding Point and Feeding System of Coal Shale

This measure aims at heat saving by changing the feed point of coal shale from direct feeding into the F.F furnace to the C4 cyclone inlet, as well as by changing the feeding system from a pneumatic to a mechanical system.

As this measure is specific to APMC Rawang Works, it cannot be diffused to the whole of Malaysia. Thus the total energy saving is limited to the estimated value for APMC Rawang Works.

(5) Reduction of Cyclone Pressure Loss

This measure aims at power reduction by reducing pressure loss in the cyclones.

(6) Improvement of Bottom Cyclone Collecting Efficiency

This measure aims at heat saving by improving bottom cyclone efficiency followed by reduction of the exhaust gas temperature.

(7) Waste Heat Boiler/Power Generating System

This measure aims at waste heat recovery by installation of waste heat boiler/power generating systems. By the waste heat boiler, steam is generated utilizing the heat of hot exhausted gas. Generated steam is utilized for power generation in the steam turbine power generating system.

(8) Lifter Bricks at Kiln Backend Part

This measure, aimed at fuel reduction, involves the laying of lifter bricks at the kiln backend part, which enables effective burning of unburned fuel that is brought into the kiln from the pre-heater section.

(9) Replacement of Cooler GBF

By replacing the existing Gravel Bed Filter (GBF) with an Electrostatic Precipitator (EP), heat and electricity saving are expected as well as recovery of clinker. This measure is specific to APMC Rawang Works and cannot be diffused to the whole of Malaysia. Thus the energy saving is limited to heat and electricity saving in APMC Rawang Works.

(10) Grinding Aids

This measure aims at power saving in the grinding mill by utilizing grinding aids.

Table 13-3 Energy Efficiency Promotion Potential in Cement Industry

Measures	Electricity	Fuel	Total Energy	
	10^6 kWh/y	10^9 kcal/y	10^9 kcal/y	% of Current Energy Consumption
Energy Efficiency Promotion Potential				
Prevention of air leakage	48.3	0	109	0.76
Rationalization of transportation system	20.2	0	45.5	0.32
Construction of coal dryer/grinding mill	-2.3	119	114	0.80
Change of feeding point and feeding system of coal shale	0	8.2	8.2	0.06
Reduction of cyclone pressure loss	12.7	0	28.6	0.20
Improvement of C5 cyclone collecting efficiency	- 4.2	128	119	0.83
Waste heat boiler/generator system	381	0	858	6.0
Lifter brick at kiln backend part	0	149	149	1.0
Replacement of cooler GBF	0.96	30	32.2	0.22
Grinding aids	3.8	0	8.6	0.06
Total (1)	460.46	434.2	1,472.1	10.3
Current Energy Consumption (2)	1,610	10,700	14,300	
Energy Efficiency Promotion Potential (1) / (2) x 100	28.6%	4.06%	10.3%	

Table 13-3 shows energy-saving potential assuming diffusion of the recommended energy-saving measures, as well as the ratios of potential to total energy consumption. 460 GWh/year of power saving and 434 x 10^9 kcal/year of fuel saving are estimated. Energy-saving potential, a total of power and fuel saving potential, is 1,472 x 10^9 kcal/year in terms of the primary fuel, accounting for 10.3% of energy consumption in the Malaysian cement industry. The potential is 147,200 TOE/year.

13-6 Energy Efficiency Promotion Potential in Food Industry

Energy use varies significantly according to the product. The energy used in the factory for wheat flour, wheat bran, etc. is about 160,000 kcal/ton; that for monosodium glutamate and others is about 5,150,000 kcal/ton; and that for biscuits is about 960,000 kcal/ton. Because of the wide variety of products produced by these factories and the types of energy use, it is quite difficult to characterize the food industry in terms of energy use and even more difficult to estimate energy efficiency promotion potential by this method.

Even if discussion narrows down to the sugar refining branch, it is difficult to estimate the potential for the whole of Malaysia, since the recommended measures are strongly affected by the model factory's characteristics. The model has quite a large boiler capacity to supply steam to its own power plant, which seems a unique feature of the factory, and the recommended measures are concentrated on the boiler and steam system. Therefore, it is unreasonable to estimate the energy-saving potential for the whole of Malaysia by this method.

13-7 Energy Efficiency Promotion Potential in Iron/Steel Industry

The energy efficiency promotion potential by diffusion throughout Malaysia of the following measures that were recommended for ASM is estimated under assumptions set for each measure.

(1) Reduction in Temperature Variation of Extracted Material

This measure aims at fuel reduction in the reheating furnace by reducing the temperature range of extracted billet to the lower side.

(2) Reduction in Air/Fuel Ratio of Reheating Furnace

This measure aims at fuel reduction in the reheating furnace by reducing the current air/fuel ratio to the optimum attainable level.

(3) Reduction in Heat Loss from Reheating Furnace Wall

This measure aims at fuel reduction in the reheating furnace by reducing the heat loss from the furnace wall.

(4) Introduction of Hot Billet Charging

This measure aims at fuel reduction in the reheating furnace by hot billet charging.

(5) Reduction in Electricity Consumption of EAF

For ASM, it is recommended that the oxygen lance position be well into the molten phase and influence the metal phase, so that the boiling reaction is not localized only in the slag phase. Electricity could be saved for other EAFs throughout Malaysia, although specific measures may vary with individual plants.

Table 13-4 shows energy efficiency promotion potential, assuming diffusion of the recommended measures. 36.8 GWh/year of power saving and 69.4 x 10^9 kcal/year of fuel saving are estimated. The potential, a total of power and fuel saving potential, is 152.2 x 10^9 kcal/year in terms of the primary fuel.

Table 13-4 Energy Efficiency Promotion Potential in Iron and Steel Industry

Measures	Electricity	Fuel	Total Energy
	10^6 kWh/y	10^9 kcal/y	10^9 kcal/y
Reduction in Temperature Variation of Extracted Material	0	13.4	13.4
Reduction in Air/Fuel Ratio of Reheating Furnace	0	14.5	14.5
Reduction in Heat Loss from Reheating Furnace Wall	0	20.6	20.6
Introduction of Hot Billet Charging	0	20.9	20.9
Reduction in Electric Consumption of EAF	36.8	0	82.8
Total	36.8	69.4	152.2

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