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JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

MINISTRY OF INDUSTRIES
ROMANIA

STUDY ON ENVIRONMENTAL POLLUTION CONTROL AND ENERGY SAVING IN THE INTEGRATED IRON AND STEEL WORKS "SIDEX" S. A. GALATI IN ROMANIA

FEBRUARY 1995

Kobe Steel, Ltd.

Nippon Steel Corporation

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PREFACE

In response to a request from the Government of Romania, the Government of Japan decided to conduct a study on Environmental Pollution Control and Energy Saving in the Integrated Iron and Steel Works "SIDEX" S.A. Galati in Romania and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Romania a study team headed by Mr. Hiroshi Tsutsumi, Kobe Steel, Ltd., three times between November 1993 and December 1994.

The team held discussion with the officials concerned of the Government of Romania, and conducted field surveys in the study area. After the study team returned to Japan, further studies were conducted and the present report was prepared.

I hope that this report will contribute to the Environmental Pollution Control and Energy Saving in the Integrated Iron and Steel Works "SIDEX" S.A. Galati in Romania and to the enhancement of friendly relations between our two countries.

I wish to express my sincere appreciation to the officials concerned of the Government of Romania for their close cooperation extended to the study team.

February 1995

Kimio Fujita
President
Japan International Cooperation Agency

INTRODUCTION

1 The Sidex SA Galati (Sidex) integrated iron and steel works on the river Danube in Romania, which is the subject of the brief paper, has a capacity to produce around 10 million tons of crude steel. It is the largest steelworks in Eastern Europe. Production has recently been decreasing mainly due to shortage of raw materials and energy.

2 An ongoing and fundamental task which it faces is the immediate necessity to improve the environmental impact which Sidex has on the Danube and the approximately 400 thousands residents in the Galati area.

3 The lack of environmental protection is a legacy of the heavy industrial policy of the former socialist "planned" economy. Romania suffered under this policy more than most as it was probably the most rapidly developing country in Eastern Europe.

4 During this forty years a low priority was given to environmental issues and virtually no consideration was given to adverse impact. Little investment was made in protection or preservation of the environment. The price is now being paid for this lack of foresight. Another consequence of this philosophy was that the price of energy resources such as petroleum and natural gas built into investment decisions was set extremely low so a great deal of precious resources were just wasted and the resultant waste products further added to environmental degradation. The resultant effect became a critical issue for the new regime and has resulted in new and urgent priorities for the management.

5 From the 26th of October 1992 until the 12th of November 1992 discussions were held between the Romanian and Japanese Governments on the problems which existed generally throughout this part of Eastern Europe (Romania, The Czech Republic and Slovakia). A program of technical assistance in the field of energy conservation, environmental protection and pollution control was agreed upon with Sidex chosen as a case study. This choice was based mainly on the probable impact any improvement would have on the three other major steelworks in Romania.

6 From the 20th of March to the 29th March 1993, a feasibility group visited the Sidex Plant to take an overview of energy utilization and environmental pollution. Their object was mainly to plan for the preparatory study and following this visit on the 21st of June 1993 an agreement was signed with Ministry of Industries and Sidex management on the scope of work of the Study.

7 The object of the Study is to analyze the present situation at Sidex in order to design a program to improve energy utilization efficiency, to reduce contaminant release and to improve the environment. The scope of work agreed to achieve this was as follows:-

Measures for energy saving (fuel, electric power and steam)

- i Coke oven batteries (including Coke Dry Quenching),
- ii Sintering plants,
- iii Blast furnaces (including hot stoves),
- iv Reheating furnaces.

Measures for environmental protection (dust, sulfur oxides, nitrogen oxides, wastewater and other waste)

- i Coke oven batteries and Coke chemical plants,
- ii Sintering plants,
- iii Blast furnaces.

8 The Study was carried out in accordance with the procedure described in the basic agreement as follows:-

"There are various facilities of the same type in Sidex. As some facilities do not need to be operated according to the production plan and some facilities are classified into the same category, a plant is chosen as a model from respective facilities. The conceptual design only for that model is studied and that design is applied to other facilities."

9 The following were selected as the models:-

- i No.5 Coke oven battery (including No.2 CDQ) and the corresponding Coke chemical plant,
- ii No. 6 and No. 7 Sintering plants,
- iii No. 6 Blast furnace (including a hot stove),
- iv Hot rolling mill No. 1 Reheating furnace.

On the 18th November, 1993, the inception report was submitted to the government of Romania, where the way of investigation, the organization of the field survey, its schedule, and questionnaires are involved. During the Study it was found that as a result of the Sidex production plan, parts of the plant were not available for use as a model because of shutdown for example. In such cases and based on the agreement with Sidex, a similar plant was selected as a model and investigated. In addition, Sidex requested that a few additional plants were added to the Study for various reasons and all these matters are described in the report.

10 The first field survey was carried out from the 22nd of November to the 18th of December 1993. At that moment, JICA explained the inception report at first, and SIDEX and JICA agreed the object as well as the way of investigation mutually, and the study began. The results and preliminary ideas on possible improvements were summarized in the Interim Report. This was submitted to the Romania Government on the 16th of June 1994.

11 The second field survey was carried out from the 6th of July to the 10th of August 1994. This Second Survey carried out supplementary investigations of the model plants to investigate the costs and effects of possible measures. It also discussed more deeply the contents of Interim Report, the financial arrangements and investigations of the effects on related plants.

12 After the second field survey, all available data and information such as the present problems, its causes, its possible solutions, the cost of investment, the implementation schedule, and so on was compiled in one book, a Draft of

Final Report, and it was submitted on the 16th November, 1994. The Summary of the Draft Final Report was, as well, submitted on the 22nd November, 1994.

13 The third field survey was carried out from the 26th of November to the 13th of December 1994. The purpose of the third field survey was to make an explanation about the Draft of Final Report to the Romanian counterparts, and then the contents of the Draft was agreed by the Romanian party and JICA. (On the 6th of December, 1994, the minutes of meeting was made and signed between the Romanian government and JICA.)

14 After discussions and approval by Sidex and Romania Government at the third field survey, the Final Report is submitted to the Government of Romanian in February 1995. The Study and the Final Report was facilitated by the wholehearted cooperation and support from our Romanian colleagues, especially those in the Ministries of Industry and Environment and in the Sidex management. The Japanese study team wishes to express its sincere appreciation.

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Appendices

Abbreviation

BF	(Blast Furnace)
BFG	(Blast Furnace Recovery Gas)
BTX	(Benzene, Toluene, Xylene)
CDQ	(Coke Dry Quenching System)
COB	(Coke Oven Battery)
COG	(Coke Oven Recovery Gas)
EP	(Electric Precipitator)
HC	(Heat Consumption)
HS	(Hot stove of Blast Furnace)
LDG	(LD Convertor Recovery Gas)
PCI	(Pulverized Coal Injection System)
RF	(Reheating Furnace)
RSW	(Ring Slit Washer type Scrubber)
SIDEX	(Integrated Iron & Steel Complex SIDEX S.A. Galati)
TRT	(Top Pressure Gas Recovery Turbine)

I. STUDY OF THE BACKGROUND

1. ECONOMIC CONDITIONS AND STEEL INDUSTRIES OF ROMANIA

1.1 Outline of the Present Economic Trends of Romania

After the revolution in December 1989, planned economy under former socialism economic structure was drastically transferred to the market economy. The new regime has conducted a rather gradual transfer of the economic system to the market economy. However, old economic constitution could not well timely cope with the new situation and abolition of government subvention to the producers based on price liberalization incurred an increase of consumer prices and unemployment.

The followings shows the changes of economy indices after the year of revolution (data from Anualrul Statistical Romaniei, etc.);

(1) Growth Rate of GDP (in percentage against previous year)

1990	1991	1992	1993*1
-5.6	-12.9	-13.5	1.0

(2) Consumer Price (in percentage against previous year)

1990	1991	1992	1993*1
105.1	274.5	310.9	355.1

Remarks)

According to the recent data from January, '94 to May, '94, average increase rate of consumer price is 6.0% which was approximately half the figure of the same period of the last year and seems to becoming stable in lower level.

(3) Unemployment percentage

1990	1991	1992	1993*1	1994*2
—	3.0	8.4	10.2	10.9

*1 : Tentative figure

*2 : Figure of June '94 and number of unemployment was registered 1,243,813.

1.2 Status of Privatization

According to the Council for Coordination of Strategy and Economic Reform, various policies are issued with priority given to the privatization of industries in the market economy, one of which is "the Law on Restructuring of State Enterprises into Government Corporations and Private Companies" established in August 1990. The "Enterprise Privatization Act" established in August 1991 stipulates the restructuring procedures. According to the Acts, the 70% of the stocks of an enterprise will be transferred to the state ownership fund and the remaining 30% to the private ownership fund. All the Romanian population older than 18 years will be given coupons free of charge, which can be changed with the stocks of this 30% whenever the stocks are opened to public in future.

Another important privatization policy is embodied in the establishment of "Management Contract Law." The management staff of the state enterprises were conventionally said to lack incentive mainly because of no reward for the achievement of given management targets. To improve the situation, this law stipulates that business objectives are auctioned to recruit managers and that the manager are assigned the owner of the enterprise when the objectives are achieved. Participation from abroad is possible.

This way, privatization is vigorously promoted. But few companies are showing profits presently yet and attractive for entrepreneurs to invest. Even if any profit could be expected, such profits are offset against the high inflation, thus discouraging the desire for investment.
However, owing to the money tightening policy targeted in the stand-by agreement made by IMF in December '93, inflation rate is somewhat calming down to lower level forming favorable circumstances to the investors.

1.3 Industrial Production

1.3.1 General

Due to the shortage of foreign currency actualized by collapse of COMECON where trades were made on the basis of account settled and the shift to the foreign currency settlement and due to disintegration of areal raw material/fuel supply network in the league, Romanian industries were encountered with the worst situation in procurement of raw materials. This has caused sharp drop in industrial production as shown in Table I.1-1

Table I.1-1. Transition of Industrial Production Index
(in percentage against previous year)

1990	1991	1992	1993*1
-19	-19.7	-21.8	0.8

*1 : Tentative figure

1.3.2 Capacity utilization of the metallurgical industry

The capacity utilization of the metallurgical industry including nonferrous metal is as low as half of the peak level as shown in Table I.1-2.

Table I.1-2. Transition of Capacity Utilization (100% as of 1989)

1990	1991	1992	1993
65	55	57	–

1.3.3 Transition in the production of the iron & steel industry

Compared with the crude steel production of 14 million tons before the Revolution, the production in 1992 is as low as 37% of the peak level as shown in Table I.1-3:

Table I.1-3. Main Steel Product Mix in Romania 1989-1992

(Unit: 1,000 t)

	1989	1990	1991	1992
1. Total production of crude steel	13,414	9,106	6,638	5,029
2. Total of products				
	10,263	6,787	5,163	3,816
3. High processing products				
• Seamless steel pipes				
• Cold rolled plates and sheets	823	590	288	251
• Cold drawn wire	1,108	755	659	441
• Special and coated plates and sheets	545	410	315	198
• Welding electrodes	76	64	35	40
• Calibrated steel				
• Steel ropes	63	65	35	40
• Tire strand	200	159	145	70
	39	27	22	19
	10	5.6	4	3.5

Data from the Department of Metallurgical Industry, Ministry of Industries

1.4 Iron and Steel Sector Policy, Projects, and Programs

1.4.1 General

Department of Metallurgical Industry, Ministry of Industries has conducted the study for the strategy of the whole Romanian iron & steel industry for 10 years from 1992 to 2002, with the PHARE fund.

The study was carried out by French consulting company SOFRES-CONSEIL

This results, together with the results of the modernization plans framed by the corresponding steel industries and institutes including IPROMET under the Romanian Ministry of Industries, are compiled by the Department of Metallurgical Industries as "Strategy for Restructuring of Romanian Iron and Steel Metallurgy".

The strategy, through its final approval by the Inter-Ministerial Committee, was finally approved by the Parliament in February, 1994 as the strategy of the whole Romanian iron & steel industries.

The Strategy quantitatively predicts future changes in the consumption and demand of iron and steel, proving more concrete than the restructuring plan ever disclosed.

1.4.2 Future projection of the iron & steel industry

The following analysis is based on "Strategy for Restructuring of Romanian Iron and Steel Metallurgy" issued by the Ministry of Industries.

According to this restructuring plan, restructuring and modernization are first required to make the Romanian iron & steel industry productive and competitive, for which the following basic policies need attention:

(1) To bring the capacity utilization of steel industries to about 80% by harmonizing the production capacity with the demand through reduction of unnecessary assets.

(2) To obtain competitiveness both in production cost and quality by gradually decreasing the technological difference from the world advanced iron and steel industries.

Then, as the main strategy for restructuring the Romanian iron & steel industry for the year 2002, the following measures need execution:

(1) To make SIDEX and the Calarasi works the strategic points for the supply of flat products, long products, and their semifinished products because these works, located along the Donau, are excellent in the transportation of raw materials and in the shipment of products.

(2) To make the Hunedoara works the main plant of long products because its location, in the central part of Romania, is excellent in its nearness to the production area of iron ores and coal.

(3) To restructure small iron- and steelworks scattered in the country as minimills consisting of electric arc furnace - continuous casters - rolling mills.

1.4.3 Production plan and demand

Estimation of the domestic market growth toward 2002 based on the World Bank's GDP growth rates is shown in Table I.1-4.

Table I.1-4. World Bank Estimations of Romanian Economic Growth 1989-2002

(Unit:%)

Indicator	Yearly increase percentage								
	1989	1990	1991	1992	1993	1994	1995	1996	1997-2002
1. Gross Domestic Product (GDP)	100	-6.2*	-13.0*	-5.2*	-1.8	1.0	2.9	3.5	4.7
2. Economic Branches									
• Agriculture	100	-12.5	-1.6	-5.0	-1.0	2.5	4.0	4.0	3.7
• Industry	100	-19.2	-20.0	-7.9	-3.0	-0.7	2.0	3.0	4.6
• Services (including public constructions and transports)	100	6.4	-8.2	-2.0	-2.0	2.0	3.4	3.7	5.4
• Exports	100	-46.8	-18.3	5.4	5.0	5.5	5.8	5.8	6.4
• Imports	100	-10.6	-25.1	-4.6	1.5	2.3	2.9	2.9	4.8
3. GDP Index	100	93.8	81.6	77.3	76.0	76.7	78.9	81.7	102.0
4. Industry Index	100	80.8	64.2	59.1	59.1	56.9	58.1	59.8	74.9

*Compared with the World Bank estimations, the growth rate of gross internal product was -7.4% in 1990, -13.7 % in 1991, and -15.0 % in 1992.

The corresponding structure of steel products demand in 1996 and 2002 is shown in Table I.1-5.

Table I.1-5. Forecast of Production and Demand

(Unit: 1,000 tons)

	1996	2002
<Domestic consumption>		
Domestic production		
• Semifinished products for forging	255	320
• Seamless pipe	320	351
• Long products	1,900	2,333
• Flat products	2,000	2,502
Subtotal	4,475	5,506
Imports		
• Long products	100	120
• Seamless pipe	25	30
• Special semifinished products	30	40
Subtotal	155	190
Total of domestic consumption	4,630	5,696
<Exports>		
• Long products	760	1,000
• Flat products	1,070	1,410
• Seamless pipe	220	315
Total of exports	2,050	2,735

As seen from the above table, the production in the year 2002 will be 8.241 million tons (9.5 million tons as crude steel). Then with the capacity utilization 80%, the present total production capacity of the major five iron- and steelworks, 17.7 million tons, will have to be reduced to about 12 million tons.

The production of SIDEX (production capacity 6.95 million tons) and Calarasi works, through full utilization of the geographical advantages as situated along the Donau and centering of production in these two works, will reach 72.2% of the whole Romanian production.

Outline of the production sharing and the capacity utilization of the main iron- and steelworks in 2002 after restructuring is shown in Table I.1-6.

Table I.1-6. Sharing of Production and Capacity Utilization in 2002

(Unit: 1,000 tons)

	Capacity	Production	Capacity utilization
• SIDEX, Galati	6,950	5,570	80.1%
• SIDERURGICA, Hunedoara	1,550	1,210	78%
• SIDERCA, Calarasi	1,700	1,400	82%
• Others	1,785	1,320	72%

1.4.4 Raw materials and fuels

The Romanian production of iron ores was about 1.46 million tons in 1991 and about 1.3 million tons in 1992 and the self-supply rate was about 16%. The production, however, is on the decrease from 3.2 million tons in 1970s and almost all the required 10.4 million tons of iron ore and pellets for the year 2002 is expected to be imported.

Dependency of Romanian demand of raw materials on the former USSR was high, which has caused confusion due to collapse of COMECON. Table I.1-7 shows the procurement plan of raw materials and fuels in 1996 and 2002.

Table I.1-7. Procurement of Raw Materials and Fuels in 1996 and 2002

		1996	2002
(1)	Requirement of iron ore and pellets (1,000 t/y)	7,200	10,400
	• Import from the former USSR and Brazil	6,900	10,100
	• Domestic production	300	300
(2)	Requirement of scrap iron (1,000 t/y)	3,550	4,195
(3)	Requirement of coking coal (1,000 t/y)	3,600	4,600
	• Import	2,450	2,980
	• Domestic production	1,150	1,620
(4)	Requirement of coal for PCI (1,000 t/y) (All to be imported)	300	800
(5)	Requirement of natural gas (MNm^3/y)	2,090	2,180
(6)	Requirement of electricity (million MWh/y)	5.23	5.46
(7)	Requirement of fuel oil (1,000 t/y)	49	47

Presently, each sector of the iron and steel industry tries to secure the raw materials needed for continuous production by bartering the products for raw materials and fuels or by triangular trade. In SIDEX, for example,around 95% of the export income is used for bartering for raw materials and fuels and the remaining 5% is received in foreign currency and used for purchase of spare parts, etc. If export products shown in Table I.1-5 are sold at US$330/t-product, 70% of the foreign currency needed for import of raw materials and fuels in Table I.1-7 will be secured. In other words, 70% of the money needed for import of raw materials and fuels will be secured by exporting 33% of the products manufactured.

1.5 Modernization Program and Investment Cost

Modernization toward the year 2002 requires not only introduction of advanced technologies but also revamping of the existing old production processes.
That is, the target of BOF steelmaking rate and continuous casting rate, based on the actual 55.4% and 42% in 1993, is 72.2% and 97% in 2002, respectively.

On the other hand, the Council for Coordination of Strategy and Economic Reform recognizes that modernization should come before privatization. Its financial measures, however, should be studied for each strategy. The most expectable financial sources are:

- State ownership fund, which require approval of Parliament
- Bank credit
- Escrow account

Modernization of SIDEX should preferably be financed by the loan of the Institutional Finance of Japan, for example.
In terms of environmental protection measures, State ownership fund can be considered, but it should be applied within the framework of social protection. Therefore, application of the State ownership fund to SIDEX's energy saving and environmental protection will invite an considerable argument

According to the report of the Ministry of Industries (Strategy for Restructuring of Romanian Iron & Steel Metallurgy), the investment cost needed for the restructuring toward 2002 is estimated by the Institutes at about US$2,645 million, of which US$1,010 million is investment on foreign currency. These required amounts of money will consist of the own funds of each industry sector by 40.9%, bank credits by 34.3%, and capital increase by 18.6%. See Table I.1-8.
However, this is not easy for the industries because each sector of the iron

& steel industry is tight even in securing foreign currency for purchase of raw materials and fuels.

Table I.1-8. Investment Efforts Required for the Main Iron- and Steelworks as well as the Financing Sources

(Unit: Million US$)

Iron- and Steelworks	Investments total	Financing sources			
		Own sources	Government budget	Bank credits	Capital increase
SIDEX, Galati	1,378	700	10	598	70
COST + OTELINOX, Targoviste	130	70	5	35	20
SIDERURGICA, Hunedoara	300	150	5	95	50
SIDERCA, Calarasi	222	30	120	20	52
CSR, Resita	62	17	10	10	25
Others	553	115	15	149	274
Total	2,645	1,082	165	907	491

1.6 Background of SIDEX

The Romanian iron & steel industry can be said to have followed its own path even within the framework of job-division system under former COMECON, but this SIDEX is said to have been constructed apart from the framework of COMECON and so the technologies applied are rather Western. However, because the first priority was placed on the heavy industry in the socialist planned economy, SIDEX now suffers from the results of the following situation:

(1) Environmental pollution problems were not paid so much attention as paid in industries in then current western countries

(2) Energy saving was not considered serious because of the comparatively cheap energies within COMECON.

(3) Introduction of latest Western technologies was not sufficient.

For example, the production of crude steel in SIDEX was 2.9 million tons in 1992, and the capacity utilization was as low as 30%. Insufficient supply of raw materials from Krivoirog contributes to this low capacity utilization in spite of its nearness to Krivoirog, and the BF productivity is as low as 1.0 due to the market and the technological reasons.

Modernization plans, including environmental protection and energy saving, are on the way. In the ironmaking area, No.4 and No.5 blast furnaces, now equipped with the pulverized coal injection system (PCI system), are under modification.

For the No.1 steelmaking plant (directly connected to slab casters) which is supposed to play a major role in future, the following modernization plans are framed:

(1) Desulfurization of hot metal
(2) BOF bottom blowing
(3) Capacity increase of molten steel treatment facilities such as RH and VAD and modification of RH

Then, modification plans for the downstream processes are,
(1) Shape control of the final finishing stand by work roll shift in the hot strip mill and modification toward Level 2 control
(2) Integration of tandem mill and pickling line in the cold strip mill

1.7 Proposals from the Ministry of Industries

Presently, the Romanian iron & steel industry is a government-owned corporation and Romanian and foreign investors are not in a position to invest in the iron and steel industry in Romania. Correspondingly, the Ministry of Industries proposes that the Romanian Government should provide legal and systematic assistance to the achievement of the following policies of the Romanian iron & steel industry:

- To meet the domestic demand for high-quality steels at prices lower than those of the world
- To secure foreign currency needed for purchase of raw materials and fuels and for introduction of advanced technologies required for modernization by conducting export

Correspondingly, the Ministry of Industries proposes the following to the Government as urgent national needs within the framework of the Strategy for Restructuring of the Romanian Iron & Steel Metallurgy:

(1) To downsize the production facilities, having the capacity of 17.7 million tons, to the level that meets the domestic and foreign demand in 2002.

(2) To give assistance to investors at prime rate by using the governmental fund and to provide government guarantee needed for obtaining loans from international financial corporations. For the coming several years, investment of US$1,200 million is needed, of which US$400 million foreign currency is needed for introduction of advanced technologies and equipment.

(3) To prepare public investment programs for improvement of the infrastructure such as roads, railways, houses, and cultural activities. These programs should be able to activate the Romanian economy, to accelerate early participation of Romania in the economy of the Europe or the world, and also to motivate the people toward activation. Resultantly, these programs are expected to bring about yearly steel consumption of more than 1 million tons, equal to 20% of the domestic consumption in 2002.

(4) To provide tax exemption for import of the equipment and facilities needed for restructuring and modernization.

(5) To apply the social programs such as development of jobs and employment opportunities at both the national and local levels so that restructuring and modernization of the iron & steel industry can be promoted without social unrest.

(6) To collect scrap and to prepare strategies for reuse.

(7) To adjust the difference of prices among sectors of the iron & steel industry.

(8) To establish energy saving measures and guarantee systems for protection of resources.

(9) To protect domestic manufacturers during the restructuring process for expansion of the share of Romanian steel in the domestic and foreign markets;

(10) To revise the monetary policy during depression of the steel market.

(11) To approve of the Strategy for Restructuring as the Government.

2. REVIEW OF PRESENT STATUS AND FUTURE PLANS OF SIDEX

Investigations on the theme described herein are carried based on the information given by SIDEX and the interviews with the persons concerned.

2.1 Present Status of SIDEX

2.1.1 Circumstances of SIDEX

The Integrated Iron and Steel Works "SIDEX" S.A. Galati (called SIDEX), located along the Donau near the Black Sea, is the largest in Eastern Europe. Its location is advantageous in the procurement of raw materials and fuels from abroad such as the Ukraine and in the shipment of products to domestic and foreign customers.

Table I.2-1 and Fig.I.2-1. show the major production facilities and the layout of SIDEX, respectively. SIDEX is the only integrated iron- and steelworks of flat products in Romania and supplies long semifinished products to domestic rolling mills. The main steel products are plates (4 to 14 mm), hot-rolled products, cold-rolled products (0.2 to 3 mm), galvanized products, welded pipes and tubes (more than 500 mm in diameter), and semifinished products (blooms and billets).
The production of SIDEX reached its maximum 7.66 million tonne in 1989. Though it dropped down once to 2.9 million tonne in 1992 reflecting the depression, it is recovering since 1993. (Table I.2-6)

All the iron ores are imported mainly from the Ukraine, India, Brazil, and the South Africa. Coal is imported from Russia, Australia, and the North America. Domestic supply of coal, now small, will be replaced with imports in the near future. Due to shortage of foreign currency, more than 90% of the procurement of raw materials relies on the barter trade, which makes it difficult to secure long-term, stable supply of raw materials in quality and quantity, though this is quite important for stable operation of any large, integrated iron- and steelworks.

As a result of the transfer to the free economy from the planned economy by Government after 1990, negotiations with customers on sales contracts and prices have become the direct responsibility of SIDEX. SIDEX can now obtain the balance, that taxes, allotment, fund, etc. are deducted from the profits made by sales of products.

In the case of new installation or modification of the facilities, the iron- and steelworks in Romania including SIDEX can receive support and cooperation of the now privatized engineering Institutes at the various stages from planning to construction. As seen in Table I.2-2, though foreign equipment and technologies are introduced, the percentage of the equipment of Romanian make is considerably high, showing that SIDEX and these Institutes have a rich experience in the engineering of iron- and steelmaking facilities. In addition, SIDEX has a large-scale manufacturing factory for spare parts, and efficient operation of that factory is expected for modernizing the facilities further. The capability of own manufacturing in Romania is described later as Appendix-1.

Table I.2-2. Outline of Main Engineering Institutes

Name	Employment	Functions
IPROMET	750	Overall planning of steel plant facilities, coordination, economic evaluation, engineering for iron- and steelmaking, refractories, coke
IPRORAM	670	Engineering for rolling, wire rods, environment
ICEM	550	Research in iron and steel (iron and steel, refractories, coke, chemicals, etc.)
ICPPAM	725	Designing of sheet and coil products, research, detailed designing
IACMSG	8000	Construction work

Table I. 2-1. Outline of SIDEX Plant Facilities

	Designed Capacity (Kt/Y)	Started from	Main Specifications	Supplier
No. 1 BF	1050	1968	1700m³	Romania
No. 2 BF	1050	1969	1700m³	Romania
No. 3 BF	1050	1972	1700m³	Romania
No. 4 BF	1200	1975	1700m³	Romania
No. 5 BF	1850	1978	2700m³	Romania
No. 6 BF	2500	1981	3500m³	Romania
Total	8700			
No. 1 BOF Plant	3200	1968	180T/heat, LD×3 RH + VAD	Romania
No. 2 BOF Plant	3500	1975	180T/heat, LD×3	Germany (GHH)
No. 3 BOF Plant	3000	1980	180T/heat, LD×3	
EAF	250		50T/heat×3 AOD + VAD	Russia 2
Total	9950			Romania
No. 1 CC Plant	3000	1975	SL Caster(2 Strands) ×4	CONCAST 3 Romania 1
No. 3 CC Plant	2605	1981	BL Caster(5 Strands) ×5	CONCAST 1 Romania 4
Slabbing Mill	4300	1968		
Blooming Mill	2500	1982		Russia
Total	12405			Romania
Hot Rolling Mill	3500	1971	t 1.5-12 w 700-1550	Russia
No. 1 Plate Mill	1200	1966	t 4-100 w 800-3200	England+France
No. 2 Plate Mill	1500	1978	t 6-100 w 1000-4000 Low Alloy	U.S.A. + ABB
TOTAL	2700			
Cold Mill TDM No. 1	1020	1970		Germany (DEMAG)
TDM No. 2	540	1987		Russia
Reversing	84	1988		Romania
Galvanizing Plant	100	1971	t 0.3-2.5 w 600-1550	VAI+S. HEURTEY+Romania
Piping Plant		1987	d 610-1420 150000m/year	Romania
Coke Oven No. 1-4	1320	'73-75	3.8 ×12.85 ×0.46	Poland
No. 5-6	1200	'76-77	5.5 ×14.25 ×0.41	Russia
No. 7-8	1700	1982	7.0 ×15.16 ×0.41	Russia + Romania
Sintering Machine No. 1	1400	1968	156m²	Romania
No. 2	1400	1968	156m²	Romania
No. 3	1400	1978	156m²	Romania
No. 4	1400	1978	156m²	Romania
No. 5	1800	1978	200m²	Romania
No. 6	1800	1978	200m²	Romania
No. 7	5000	1981	500m²	Romania

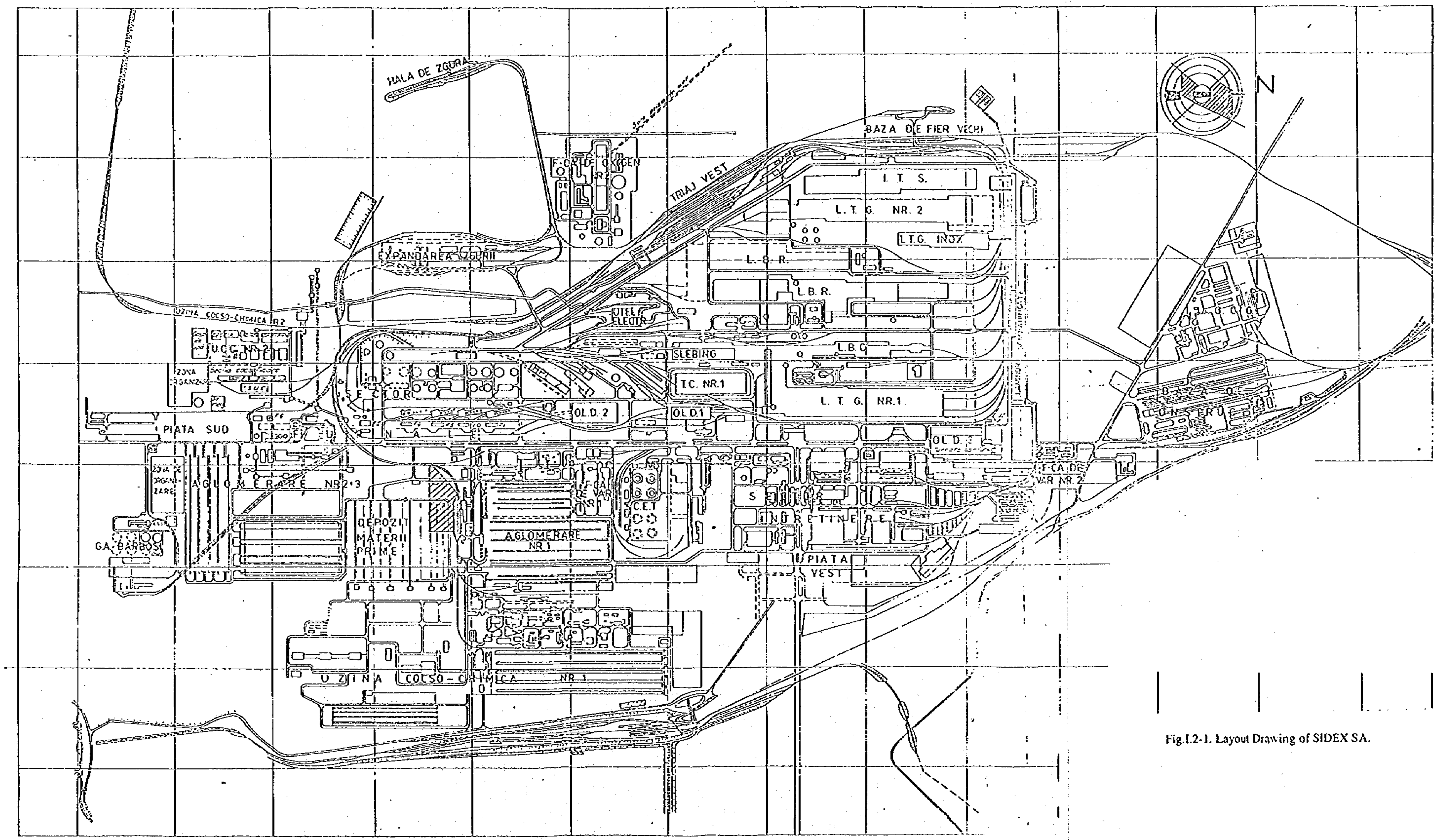


Fig.I.2-1. Layout Drawing of SIDEX SA.

2.1.2 Management of SIDEX

1) Management organization

The management organization of SIDEX, shown in Table I.2-3, consists of three major divisions, and three deputy managers of the plant control while working as the chief of each division.
Economical Division consists of the administrative dept., personnel dept., financial dept., commercial dept., general planning dept., etc., which deals with economic analysis, study of sales prices, and production planning.

As to the field of production and technologies, it consists of the Developing, Revamping & Modernization Division and the Production Division. The Production Division controls every factory from iron making to rolling and the production control dept. that actually implements and controls the production plan. The Developing, Revamping & Modernization Division covers the fields of facilities planning, technical development, major repairs, spare parts production, environmental control, and energy control.

The management organization of SIDEX is similar to the line-and-staff organization in Japan.

The main meetings in SIDEX are shown in Table I.2-4.

Table I.2-4 Main Meetings in SIDEX

• Meeting of the Board of State Representatives	:	Quarterly
• Meeting of the Board of Management	:	Monthly
• Meeting of the Board of Directors	:	Bi-monthly
• Production & Shipment Analysis Meeting	:	Daily
• Equipment and Energy Meeting	:	Weekly
• Technology and Sales Meeting	:	Weekly
• Production Technology Meeting	:	Weekly

Table I. 2-3. Management Organization of SIDEX

- Board of State Representative
- Board of Management
- Board of Directors

- General Manager
  - Assistant General Manager Economical Division
    - Administrative Manager
    - Personnel Manager
    - Financial Manager
    - Commercial Manager
    - Manager of Programming & Economic Policy
      - Economic Analysis & Reform Application
      - Economic Policy/Programming/Statistics
      - Prices & Economic Conditions
    - Leagal Office
    - Financial Control Office
    - Manager of Computer Center
  - Assistant General Manager Developing, Revamping & Modernization Division
    - Technical Manager
      - Technology & New Product
      - Nuclear Department
      - Process Modernization & Environment
      - Quality Technical Control
      - Quality Assurance
      - Laboratory
    - Manager of Mechanical & Energy
      - Mechanical Department
      - Energy Department
      - Financing Contracting Department
      - Spare Parts Equipment Department
      - Monitoring Investments & Overhauls
      - Maintenance Plant
      - Energy Plant
      - Instrument Repair Shop
  - Assistant General Manager Production Division
    - Barter Department
    - Production Manager
      - Production Programming
      - Production Control
    - Coke Chemical Plant
    - Sintering & Blast Furnace Plant
    - Steelmaking Plant
    - Rolling Mills
    - Transportation
  - Organization and Protocol Department

2) Management of the works

(1) Production planning

Concerning domestic large orders of car manufacturers, shipbuilding, construction, machinery, etc., SIDEX directly concludes the sales contracts. As for those small orders, wholesalers in various parts of the country handle and place orders with SIDEX for the products. Concerning exports, SIDEX receives orders via trading companies, including those under SIDEX. Then, based on these ordered quantities, the monthly and quarterly production plans are established and executed.

Though the government's approval is necessary for the sales prices in the country, the price can be determined by negotiations between SIDEX and customers providing that it does not exceed the international price.

(2) Budget control

The reference budgetary values from each department are compiled into the quarterly budget and put under control monthly. Each production plant has a chief engineer for accounting in equal rank to the chief engineer for operation and is in charge of cost control and reports the cost data per cost center or per product to the management.

(3) Quality control

The Quality Technical Control Department has strong functions and authorities.

- Acceptance inspection of raw materials/fuels and spare parts purchased

- Check on observation of standards in each plant and directions on actions for quality control
- Maintenance of standards and preparation for approval of ISO 9000
- Product inspection and issuing mill sheets
- Settlement of claims from customers

Quality control in SIDEX is characterized in that the inspectors belonging to the Quality Technical Control Department are assigned to the respective plants to check how the quality standards are observed and are authorized to give necessary instructions for operation from the standpoint of quality assurance.

(4) MIS (Management Information System)

The present management information systems (MIS) of SIDEX have the following functions:

- Production planning
- Materials planning
- Personnel affairs and wages control
- Production control of spare parts
- Accounting and budget control
- Filing of maintenance records

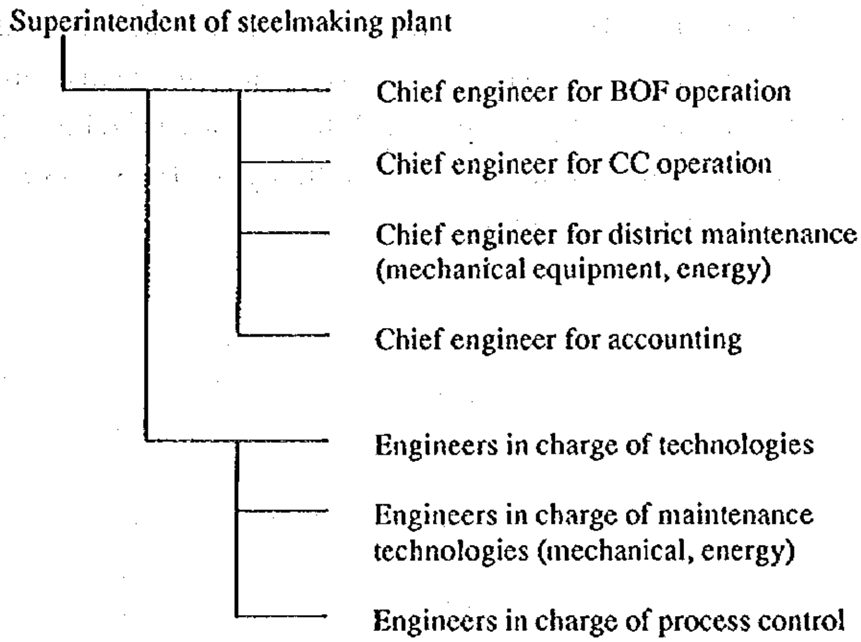
Each system mainly deals with clerical calculations and has no online functions. And so, for example, the output data sheet on a production plan from the central computer is manually delivered to each plant. Presently, replacement of the main frame computers and improvement of data and information exchanging function by connecting the terminals in all plants are on the way.

(5) Facilities control

Daily maintenance of the plant facilities is conducted by the district maintenance section belonging to the plant. Each of these district maintenance sections is under control of both the plant and the Equipment Department at the center in terms of technologies and budget common to these district maintenance sections. The Equipment Department is in charge of planning and executing major repair works such as relining of blast furnaces and also the maintenance budget of the whole works.

(6) Plant management

The plant management organization is exemplified in the case of the steelmaking plant as follows. The members are largely classified into two: those (Line) in charge of production and maintenance and those (Staff) in charge of planning of production/maintenance, collection of actual results, and technology/cost evaluation.



(7) Education and training of personnel

SIDEX has its own large education/training system. That is, SIDEX's own high schools (daytime, nighttime), a skill-training school for special technical training in iron- and steelmaking process, a qualification school, and foreman training courses for re-education and for job conversion. About 3,500 people are studying. Moreover, about 1,300 engineers and managers are receiving training a year, including those sent to universities for a short-term study of specific themes.

2.2 Future Plans in SIDEX

2.2.1 Production plan for 2002

1) Outlook of future production

Outlook of future production in SIDEX is mentioned in the Restructuring plan of Romanian iron & steel production, that the Ministry of Industries has prepared based on the said PHARE REPORT. SIDEX has its own concrete plan based on the future prospect for the market, referring to the Restructuring plan. The production plan for the year 2002, shown in Table I.2-5 is the same. Accordingly, as premises to the Study by JICA, the production shown in this table is employed.

Table I.2-5 Production for 2002 (million tons)

- Crude steel : 5.57 (equipment capacity: 6.95)
- Products : 4.85
- Hot metal : 4.77

SIDEX's past and future production amounts till 2002 by production process are shown in Table I.2-6, while the material flow in the year 2002 is shown in Fig. I.2-2 (the amount of crude steel is regarded as equal to that of molten steel in this figure).

The production amount in 2002 will be about 73% of the peak recorded in 1989. The average of increase ratio in ten years from 1993 to 2002 is 4.7 %. Economic activities in Romania largely dropped in 1990 and was depressed since. However, the domestic steel demands is recovering at the present, and therefore further smooth recovery can be expected.

The sharp decreases in export to the former communist bloc have already been covered by exports to other countries. Future prospects for the cultivation of a new market are regarded as bright. In Romania, the export of products is regarded as a means of securing raw materials which are required to meet the domestic demand.

2) Product mix

The product mix at SIDEX and deliveries of steel products from SIDEX to the domestic and foreign markets are shown in Table I.2-7. The product mix in 2002 will consist of sheet and coil products by 36%, heavy plates by 25%, and semifinished products by 39%. The major end users are vehicles, industrial machinery, household electrical appliances, shipbuilding, pipes and tubes, and railway cars. SIDEX satisfies almost all the domestic demand for sheets and plates.

With regard to the heavy plates in the products, their qualities are approved by the Lloyd's and the API. SIDEX is particularly confident in the quality of those for shipbuilding and large-diameter pipes for oil transportation, that characteristically occupy about 70% of the export products. Besides, as to the semifinished products by 39 %, SIDEX is planning to develop product items and to produce billets for seamless pipes, and will play an important part as the base supplying long materials.

Table I. 2-6. Production Amount at Each Process

Unit:1000t

	Production Result					Production Plan								
	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Hot Metal	6567	4736	3521	2508	3037	3336	3760	3896	3991	4120	4182	4287	4412	4770
Molten Steel BOF	7458	5267	3867	2826	3471	3813	4157	4478	4588	4763	4835	4986	5131	5400
EAF	204	109	68	80	94	120	164	160	160	160	170	170	170	170
Total	7662	5376	3935	2906	3565	3933	4321	4638	4748	4923	5005	5156	5301	5570
Slab by CC	2660	2028	1627	1425	1726	1950	2400	2400	2400	2400	2800	3000	3364	3368
by IC	2582	1697	1070	692	800	917	737	984	984	984	584	364	—	0
Total	5242	3725	2697	2117	2526	2867	3137	3384	3384	3384	3384	3364	3364	3368
Billet & Bloom	1434	806	684	392	598	600	720	720	820	1020	1220	1420	1620	1870
Heavy Plate	2162	1501	1120	976	1002	1065	1180	1200	1200	1200	1200	1200	1200	1200
Hot Rolled Coil	2385	1700	1205	854	1287	1540	1668	1880	1880	1880	1880	1880	1880	1884
Cold Rolled Coil	969	655	591	396	375	385	500	740	740	740	740	740	740	743
Galvanized Coil	64	52	27	30	28	35	50	60	65	70	75	75	80	80

Note: The figures of 1994 partly include actual amount

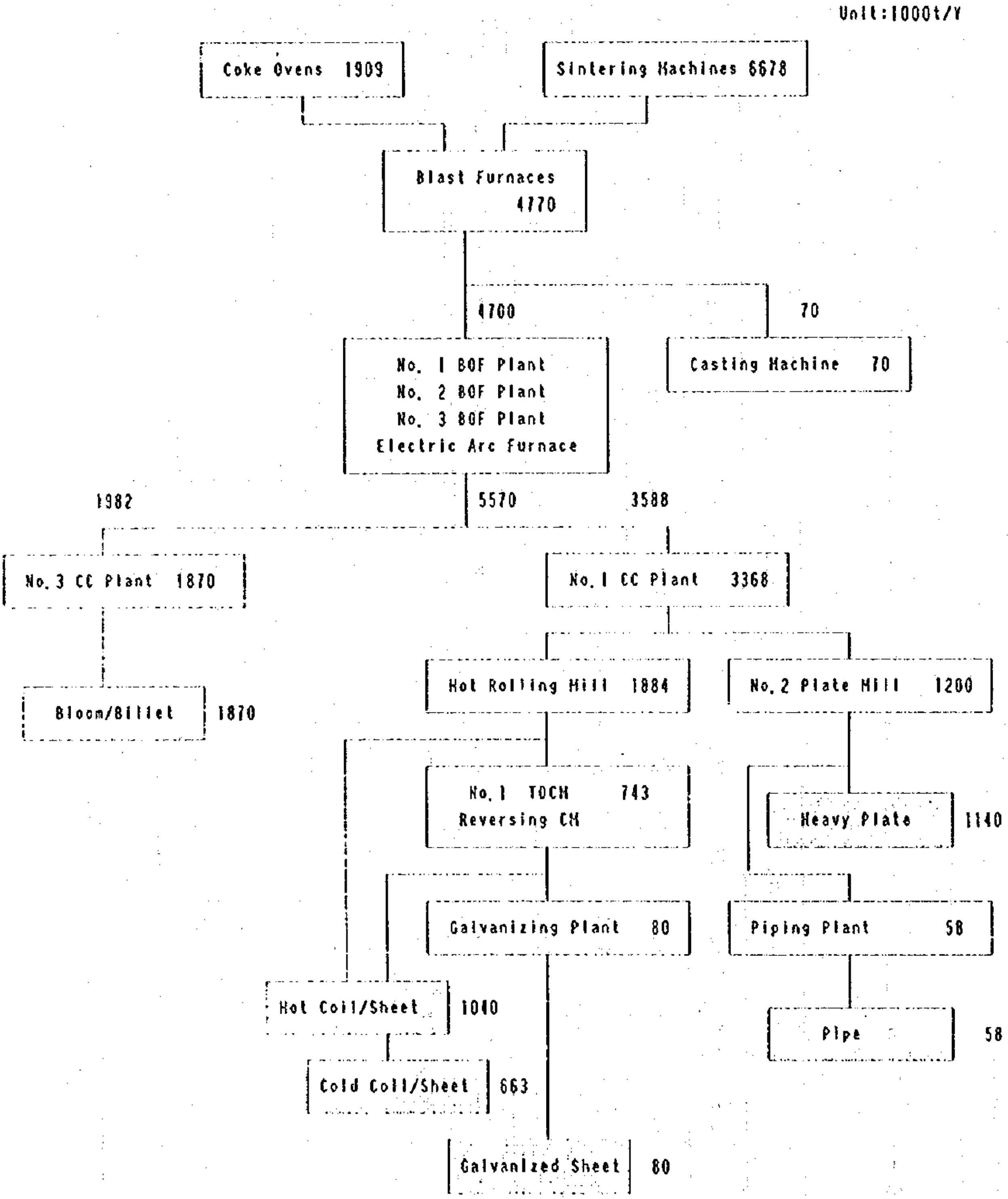


Fig. I. 2-2. Material Flow in the Year 2002

Table I. 2-7. Delivery Amount of Steel Products

Total Delivery Amount of Steel Products Unit:1000t

	1989	1990	1991	1992	1993	1994	1995	2002
Heavy Plate	2123	1440	1075	954	992	1050	1150	1140
Hot Coil & Sheet	1360	988	580	433	859	1100	1100	1040
Cold Coil & Sheet	885	590	554	357	347	350	450	663
Galvanized Coil & Sheet	64	52	27	30	28	35	50	80
Pipe	27	46	30	11	10	15	30	58
Bloom & Billet	1300	745	640	365	598	600	720	1870
Total	5759	3861	2906	2150	2834	3150	3500	4851

Delivery Amount for Domestic Demand Unit:1000t

	1989	1990	1991	1992	1993	1994
Heavy Plate	1185	695	574	336	385	400
Hot Coil & Sheet	990	924	524	326	725	850
Cold Coil & Sheet	750	530	504	317	325	340
Galvanized Coil & Sheet	23	35	19	6	19	20
Pipe	24	45	27	4	10	10
Bloom & Billet	1300	745	640	330	568	600
Total	4272	2974	2288	1319	2032	2220

Delivery Amount for Export Unit:1000t

	1989	1990	1991	1992	1993	1994
Heavy Plate	938	745	501	618	607	650
Hot Coil & Sheet	370	64	56	107	134	250
Cold Coil & Sheet	135	60	50	40	22	10
Galvanized Coil & Sheet	41	17	8	24	9	15
Pipe	3	1	3	7	-	5
Bloom & Billet	-	-	-	35	30	-
Total	1487	887	618	831	802	930

[Note] 1989 -1993 Actual amount
1994 Planned amount and actual amount
1995 -2002 Planned amount

2.2.2 Facilities operation plan

As described previously, the equipment capacity of SIDEX in 2002 will be reduced from the past so called 10 million tons/year to 6.95 million tons/year for future restructuring. The facilities operation plan for all processes to meet the situation is shown in Table I.2-8.

1) Iron-making dept.

Three (3) blast furnaces (two (2) blast furnaces in operation), three (3) sintering machines, and two (2) groups of coke ovens will be operated, while the three (3) blast furnaces, three (3) sintering machines and one (1) group of coke ovens shutdown.
SIDEX plans to shutdown Nos. 1, 2, 4 ovens working at the present, and to operate again the repaired No.8 oven. However, No.8 oven is largely damaged, and then replacement of No.7 oven will be required before 2000.

2) Steel-making dept.

As to operation of three converter shops, according to the way of increasing the capacity of continuous casting machine for producing slabs, there are two ideas; one is to stop No.2 converter shop and the other is not to close the shop. A decision is not made yet now.

3) Rolling dept.

Before 2002, the slab rolling mill will stop its operation due to the capacity increase of slab continuous casting machine, and the bloom milling machine will also stop due to new installation of billet continuous casting machine.
One out of two mills for heavy plate will stop its operation, and as to the hot strip mill and the cold strip mill they will be operated as they are.

Table I. 2-8. Facility Operation Plan in 2002

Facility	Designed Capacity (Kt/Y)	Main Specifications	Operation Plan in 2002
~~No. 1 BF~~	~~1050~~	~~1700m³~~	Not in operation
~~No. 2 BF~~	~~1050~~	~~1700m³~~	Not in operation
~~No. 3 BF~~	~~1050~~	~~1700m³~~	Not in operation
No. 4 BF	1200	1700m³	To be in operation
No. 5 BF	1850	2700m³	To be in operation
No. 6 BF	2500	3500m³	To be in operation
No. 1 BOF Plant	3200	180T/heat, LD×3 RH + VAD	To be in operation
No. 2 BOF Plant	3500	180T/heat, LD×3	Not decided at this moment
No. 3 BOF Plant	3000	180T/heat, LD×3	To be in operation
EAF	250	50T/heat×3 AOD + VAD	To be in operation
No. 1 CC Plant	3000	SL Caster(2 Strands) ×4	To be in operation
No. 3 CC Plant	2605	BL Caster(5 Strands) ×5	To be in operation
~~Slabbing Mill~~	~~4300~~		
~~Blooming Mill~~	~~2500~~		
Hot Rolling Mill	3500	t 1.5-12 w 700-1550	To be in operation
~~No. 1 Plate Mill~~	~~1200~~	~~t 4-100 w 800-3200~~	Not in operation
No. 2 Plate Mill	1500	t 6-100 w 1000-4000	To be in operation
Cold Tandem No. 1	1020		To be in operation
Mill ~~Tandem No. 2~~	~~540~~		Not in operation
Reversing	84		To be in operation
Galvanizing Plant	100	t 0.3-2.5 w600-1550	To be in operation
Piping Plant		d 610-1420	To be in operation

Coke Oven ~~No. 1-4~~	~~1320~~	~~3.8 ×12.85 ×0.46~~	Not in operation
No. 5-6	1200	5.5 ×14.25 ×0.41	To be in operation
No. 7-8	1700	7.0 ×15.16 ×0.41	Either No. 7 or No. 8 will be in operation
Sintering Machine ~~No. 1~~	~~1400~~	~~156m²~~	Not in operation
~~No. 2~~	~~1400~~	~~156m²~~	Not in operation
~~No. 3~~	~~1400~~	~~156m²~~	Not in operation
~~No. 4~~	~~1400~~	~~156m²~~	Not in operation
No. 5	1800	200m²	Either two machines of No. 5, 6, 7 will be in operation
No. 6	1800	200m²	
No. 7	5000	500m²	

2.2.3 Modernization plan

The modernization of SIDEX is aimed at the maintenance of competitiveness for quality and cost in the market, energy saving, and improvement of environment.

The main items of equipment modernization at the respective processes and their implementation time are shown in Table I.2-9. This plan is still in the stage of study, including fund raising which is the greatest problem in realizing the modernization plan.

Table I.2-9 Outline of SIDEX Modernization Plan

Facilities	Contents	Purposes
1) 1993 to 1995		
• Nos. 5 and 6 coke ovens	COG desulfurization, dust collection at the time of pushing, CDQ	Environmental protection
• No.7 sintering machine	Recovery of heat from cooler, De-dusting of main exhaust gas	Energy saving, environmental protection
• Nos. 4 and 5 blast furnaces (BF)	Pulverized coal injection	Energy saving
• No.3 BOF plant	Hot metal desulfurization, secondary refining	Quality improvement
• No.1 BOF plant	Hot metal desulfurization, combined blowing	Quality improvement
• No.1 CC plant	Prevention of gas and slag mixing, electromagnetic stirring, HCR	Improvement of quality and yield, energy saving (HCR)
• Hot strip mill	Modernization of reheating furnace, control of strip thickness and profile, RF modification (3 sets)	Energy saving (HCR), improvement of quality and yield

Facilities	Contents	Purposes
2) 1995 to 1997 • No.6 BF	Relining, PCI	Energy saving and environmental protection
• No.1 TDCM	Revamping of electrical system, control of sheet thickness and profile	Improvement of quality and yield
• No.2 plate mill	RF modification, automization, control of plate thickness and profile	Improvement of quality and yield
• Coating line	Installation of new painting line	Expansion of product mix
• Galvanizing line	Control of coating weight	Quality improvement and environmental protection
3) 1998 to 2002 • No.7 coke oven	Construction of new coke oven	Energy saving and environmental protection
• Semifinished product plant	Installation of new billet continuous casters for rails and pipes	Expansion of product mix
	Shutdown of billet and bloom mills	Energy saving

2.3 Summary

With regard to the representative indices for operation of facilities and for performances on production, Table I. 2-10 shows the comparison between SIDEX and a Japanese steelworks. Great differences are found in the indices between SIDEX and the Japanese steelworks, and the same phenomenon appears in the energy consumption of whole SIDEX and in the operation level in each factory, respectively, as mentioned in Chapter II. The followings are the main items that SIDEX needs to improve in the future.

1) Stable security of raw materials

Continuous stable supply of raw materials in long term could be one condition of stable operation in an integrated iron and steelworks. However, SIDEX encounters continual problems in securing the quantity and quality of its raw materials, which is preventing stability of operation in each step of production.

2) Engineering capabilities

Because performance, efficiency, and durability at SIDEX are not superior to those in Japan, it is necessary to analyze the conditions of the facilities by examining operational results as feedback, pointing out failure of designs, and realizing more economical designs for the future.

3) Level-up of operation control

In operating the process stably and maintaining the competitive quality and cost of product, the high technology of operation and maintenance and the capability of control greatly influence. Activities connecting all workers to be made tight, i.e. motivating all employees, solution of problems, standardization of works, observation of the standards, are important.

4) Introduction of new management concept

The management organization of SIDEX has a function of controlling the integrated steelworks, and in fact it seems to efficiently work. The production activities directly connect to the management as SIDEX is established with one steelworks, and communication in the management team is smoothly done. Hence, further improvement can be expected by observing the independency of the Line and by adopting a new management concept, e.g. setting a target, a new management system in which employees can participate with, etc.

Table I.2-10. Comparison of Major Operational Indices

1. Operational availability*

Process	SIDEX in 1989		NIPPON STEEL OITA WORKS 1992
Hot Strip Mill	Hot Strip Mill	80.2%	92.5 %
Plate Mill	No.2 Plate Mill	78.5%	93.1 %

*Operational availability(%)

$$= \frac{\text{Operating time (h)}}{\text{Calendar time (h) - Scheduled shutdown time (h)}} \times 100$$

2. Yield of each process

	Unit	SIDEX 1989	NIPPON STEEL OITA WORKS 1992
Molten Steel	%	91.5	95.8
CC Slab	%	91.3	97.1
Plate Mill	%	86.6	94.7
Hot Strip Mill	%	94.5	99.3

3. Relining interval of ovens and furnaces

	Unit	SIDEX	JAPAN
Coke Oven	Years	10-12	25-30
Blast Furnace	Years	4-5	10-15
Hot Stove	Years	4-5	15-20

II. ENERGY SAVING

1. REVIEW OF ENERGY-SAVING SITUATION IN ROMANIA

1.1 Transition of Energy Structure

Table II.1-1 shows the structure of the primary energy in these three years in the whole Romania. Under the influence of the large negative growth since 1989, the overall consumption of primary energy decreased to 76 Mt (in terms of coal) in 1992. This is a large decrease of about 30% against the past two years, and the decrease of petroleum that occupies about 70% of all is conspicuous.

Table II.1-1. Resources of Primary Energy in Romania

Resources of Primary Energy		Structure of Primary Energy (1,000 t)		
		1990	1991	1992
Coal	Coking pit coal	5,265	3,366	1,023
	Pit coal & anthracite	7,291	5,254	7,966
	Lignite & brown coal	10,302	8,801	9,421
	Imported coke	999	803	186
Petroleum	Natural gas	40,960	34,299	30,117
	Crude petroleum	34,330	21,914	19,112
	Others	2,041	3,851	3,186
Electric Power	Hydroelectric power	4,019	5,215	4,274
	Imported electric power	3,468	2,579	1,615
Others		113	76	57
TOTAL		107,906	86,158	75,934

Data from RENEL, (Coal Equivalent = 7,000 kcal/kg)

1.2 Supply and Demand of Energy in Romania

The supply of primary energy and the energy balance of export and import in Romania in 1992 are shown in Table II.1-2. Romania has domestic resources of coal, petroleum, etc., and their domestic production reaches about 70%. The final consumption structure of energy is shown in Fig. II.1-1. The energy consumption rate of the manufacturing industry occupies as much as 71% under the negative growth economy (about 45% in Japan) because of the preferential policies for the heavy industry.

1.3 Energy Consumption of Iron & Steel Industry

The energy consumption of the Romanian iron & steel industry occupies about 12% of the whole consumption in Romania. Of which, SIDEX's consumption amounts to about 73% of the whole consumption of the iron & steel industry, showing the importance of SIDEX in the promotion of energy-saving measures in Romania.

Table II.1-3 shows the energy consumption of the iron & steel industry in Romania in 1992. The production of crude steel including EAF was 5.029 million tons in 1992 and the unit consumption of energy per ton of crude steel in the whole Romania was 6.68 Gcal/t-s, higher than the Japanese average of 4.85 Gcal/t-s by about 38%.

1.4 Energy-Saving Policy and Organizations

As promoter of energy saving in Romania at the government level, the Agency Romania Conservation Energy (ARCE) is established. Its main business is consultation and supports on energy saving, but cannot be fully active because of the limitation in the fund, etc.

Table II.1-2. Energy Balance in Romania in 1992

Resources of Primary Energy		Energy Balance (1,000 t)			
		Total	Domestic	Imports	Others
Coal	Coking pit coal	1,023	877		146
	Pit coal & anthracite	7,966	2,297	5,389	280
	Lignite & brown coal	9,421	8,200	156	1,065
	Imported coke	186		186	
Petroleum	Natural gas	30,117	25,175	4,942	
	Crude petroleum	19,112	9,176	9,115	821
	Others	3,186	828	2,340	18
Electric Power	Hydroelectric power	4,274	4,274		
	Imported electric power	1,615		1,615	
Others		57	57		
TOTAL		75,934	50,007	23,743	2,184

Data from RENEL, (Coal Equivalent= 7,000 kcal/kg)

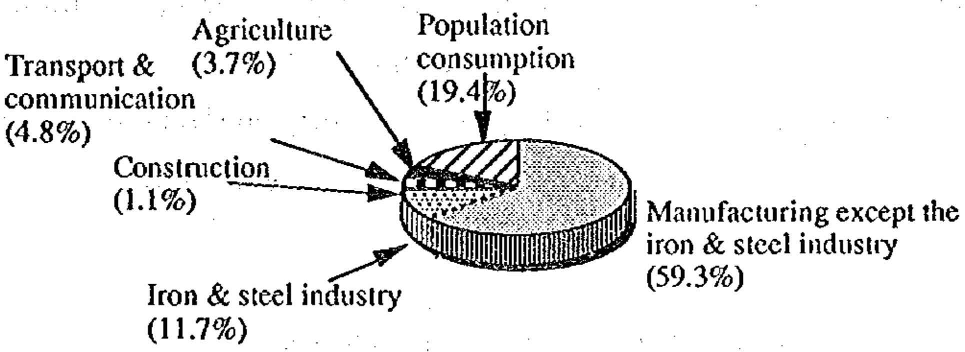


Fig. II.1-1. Structure of Consumption in 1992 (Data from RENEL)

Table II.1-3. Energy Consumption in Iron & Steel Industry (1992)

	Total	Fields (Tcal/y)		
		Ironmaking	Steelmaking	Others
Used energy	38,510	16,790	3,870	17,850
Recovery of energy	-4,920	1,430		3,590
Net consumption	33,590	Energy Unit Consumption 6.68 Gcal/t-s		

Data from the Ministry of Industries

2. SUPPLY AND DEMAND OF ENERGY IN SIDEX

The following calorific values are used throughout this Report:

• Purchased power	: 2,450 kcal/kWh (Calculated)
• Natural gas	: 8,050 kcal/Nm^3
• Raw material coal	: 7,000 kcal/kg
• Purchased coke	: 6,300 kcal/kg
• Coke	: 6,300 kcal/kg
• PCI coal	: 6,300 kcal/kg (Estimated)
• COG	: 4,250 kcal/Nm^3 (Estimated)
• BFG	: 800 kcal/Nm^3
• LDG	: 2,000 kcal/Nm^3 (Estimated)
• Steam	
High pressure	: 978 kcal/kg (Calculated)
Low pressure	: 830 kcal/kg (Calculated)

Note: According to the data supplied by SIDEX before the first survey, the calorific value of COG was about 3600 kcal/Nm^3, which seemed too low. Therefore, the second survey was carried out with the gas chromatography which was brought from Japan. As the result of the survey, the values 4,350 ~ 4,400 kcal/Nm^3 (20 times in measurement) were obtained. In this Report, counting some error, 4,250 kcal/Nm^3 is adopted as the calorific value of COG.

2.1 Energy Structure in SIDEX

The energy balance, shown in Fig. II.2-1, features the following:

1) The ratio of natural gas in the fuel energy is quite as high as 42% because of shortage of byproduct gas.

2) Concerning steam, because of much use for plant or BF blower turbine, the consumption of natural gas in the power station that supplies steam reaches about 20% of the whole natural gas consumption.

3) The in-house power generation ratio is less than 6% and the purchased power is very high in quantity and ratio.

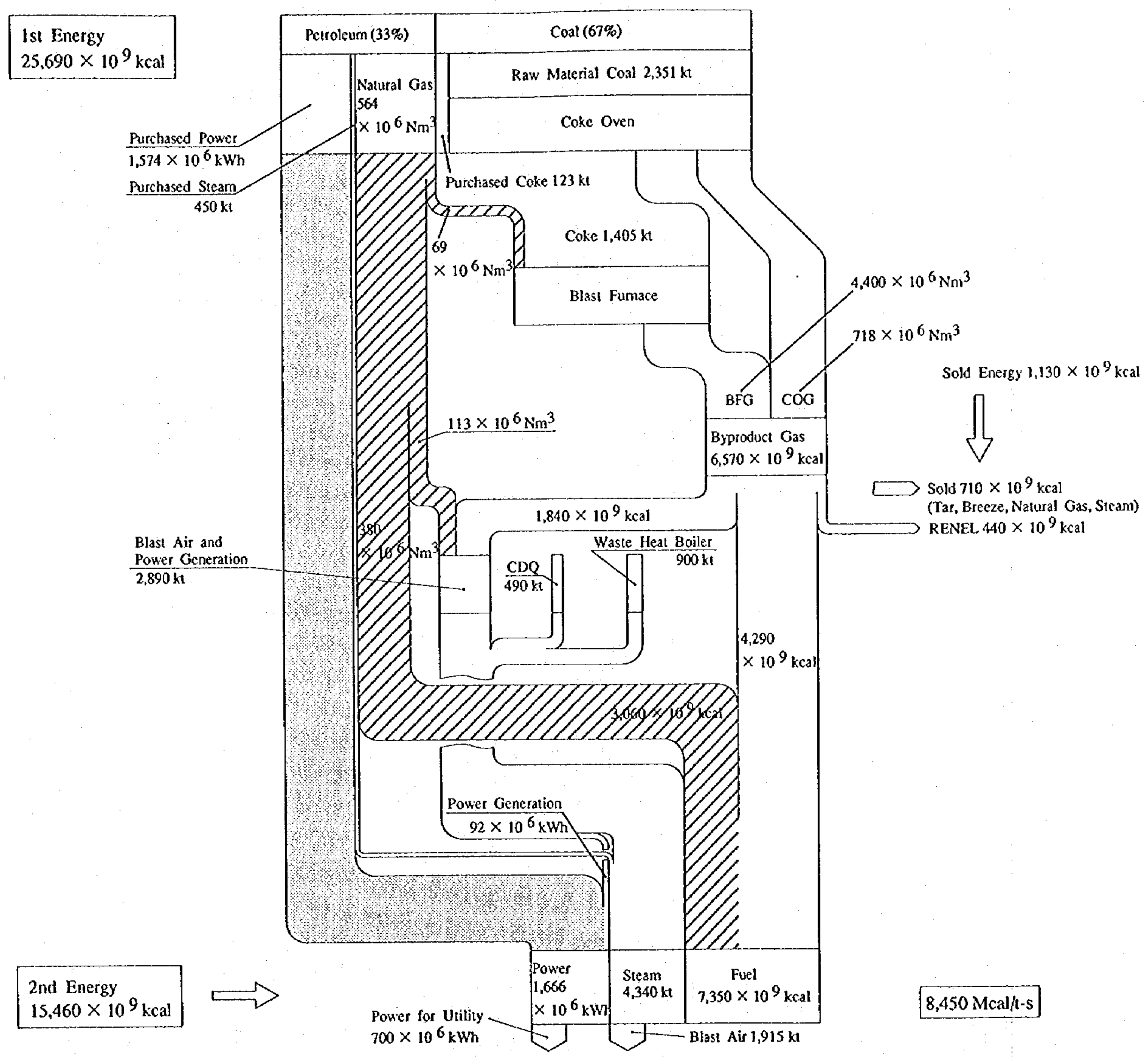


Fig. II.2-1. Energy Flow Chart of SIDEX in 1992

2.1.1 Structure of primary energy

Fig. II.2-2 compares the primary energy ratio between SIDEX and Japan. In SIDEX, coal (including purchased coke) occupies 67% and petroleum (including natural gas and purchased electric power) occupies 33%, showing that the ratio of coal is quite low compared with 93% in Japan. That is, the high unit consumption of energy can not be supplemented by byproduct gas, requiring supplementary energy (natural gas and electric power) from the outside. On the other hand, the supply of natural gas, the main source of supplementary energy, fluctuates seasonally, thus placing a limit to the operation of the works due to shortage of natural gas. Decrease of natural gas consumption is therefore most required. The breakdown of primary energy in SIDEX is shown in Table II.2-1.

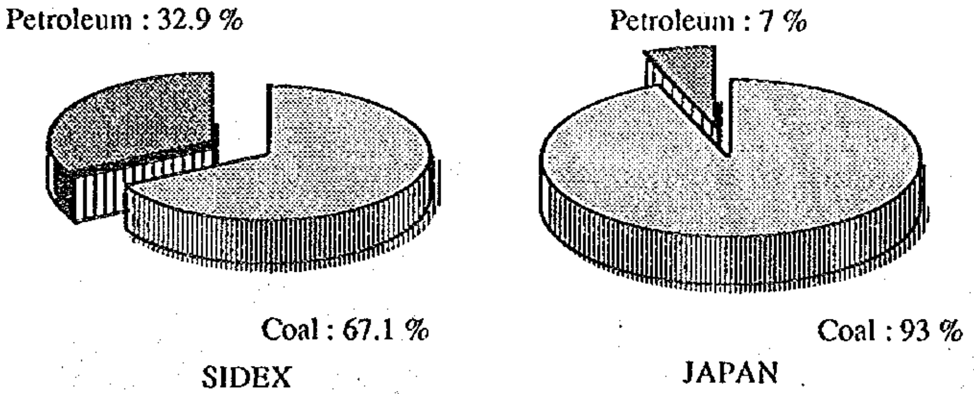


Fig. II.2-2. Comparison of Primary Energy Ratio in 1992

Table II.2-1. Breakdown of Primary Energy in SIDEX

Purchased Coal (67.1 %)		Purchased Petroleum (32.9 %)		
Coal	Coke	Natural gas	Power	Heat
2,351 x 10^3 t/y	123 x 10^3 t/y	564 MNm^3/y	1,574 GWh/y	450 x 10^3 t/y
64.1%	3.0%	17.7%	15.0%	0.2%

2.1.2 Structure of secondary energy

The comparison of secondary energy supply source between SIDEX and Japan is shown in Fig. II.2-3. In the production of the secondary energy, the energy generated in the works such as byproduct gas and recovered energy occupies about 50%, quite low compared with the Japanese 85-90% which supplies almost all the secondary energy required in the works.

Especially in fuels (Fig. II.2-4), many plants use natural gas because COG or BFG cannot be utilized effectively due to insufficient functioning of gas mixers and also because recovery and use of LDG is not conducted.

Conclusively, dependence of secondary energy on outside energy sources such as natural gas of unstable supply and purchased electric power is high in SIDEX.

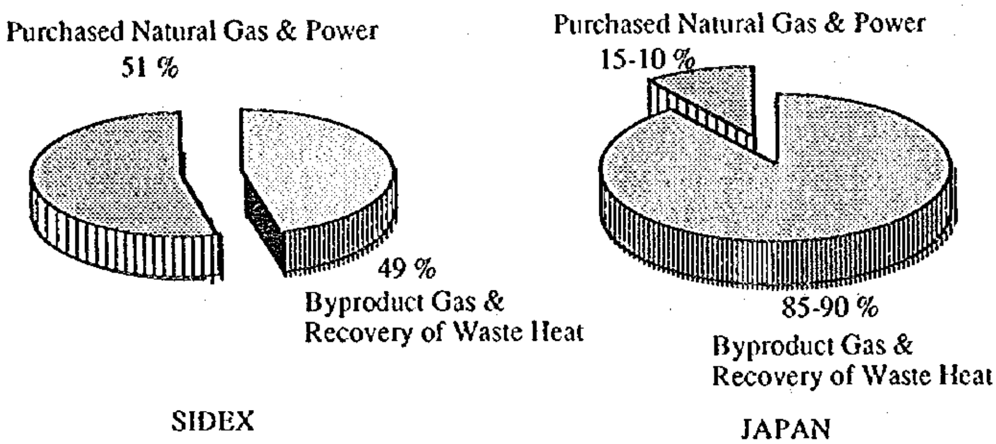


Fig. II.2-3. Comparison of Secondary Energy Supply Source

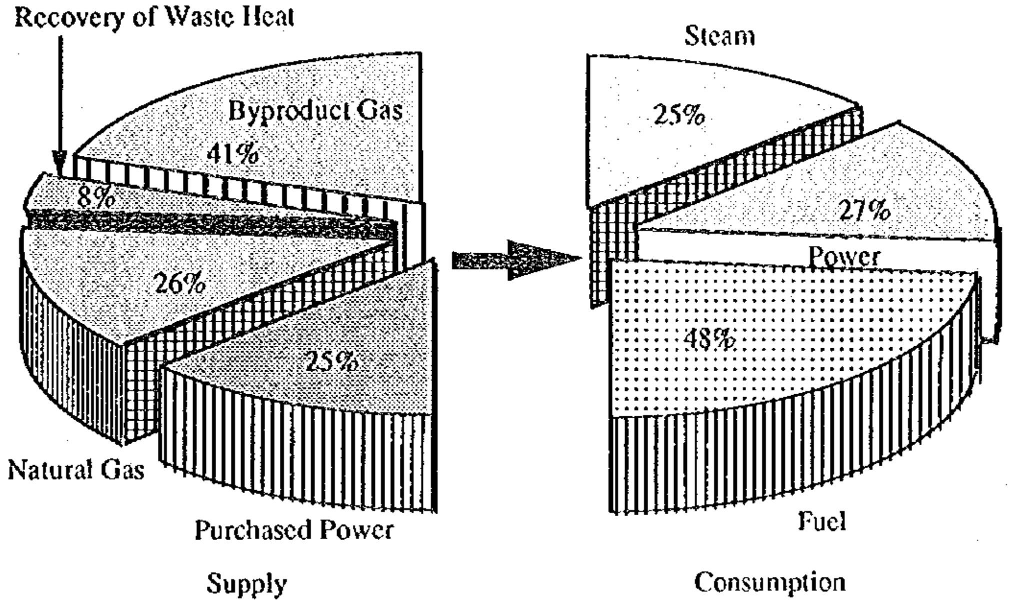


Fig. II.2-4. Secondary Energy Balance at SIDEX in 1992

2.2 Unit Consumption of Energy in SIDEX

2.2.1 Relationship among energy unit consumption, crude steel production, and total energy consumption

The relation between energy unit consumption per tonnage of crude steel and the production during these four years is shown in Fig. II.2-5.

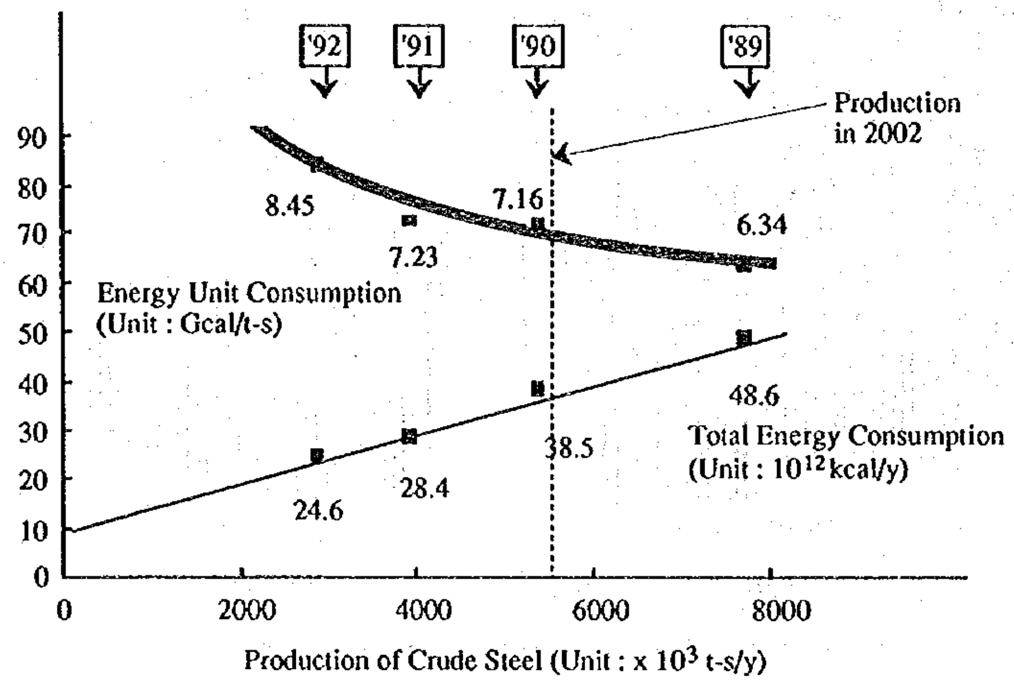


Fig. II.2-5. Relationship among Energy Unit Consumption, Crude Steel Production, and Total Energy Consumption in SIDEX ('89-'92)

The curves in the graph are quite similar to the tendency of coastal steelworks in Japan before the Oil Shock (before the execution of energy-saving measures). In SIDEX also, the energy consumption shows increase as the production increases (production proportional), while the energy unit consumption decreases as the production increases but not in inverse proportion. This may be because the energy to be consumed regardless of production quantity(fixed element) is included. The fixed element is the utilities such as steam and compressed air, thermal loss such as cooling water loss or radiation loss from furnace walls, electric power for plant lighting, etc.

The energy unit consumption, 8.45 Gcal/t-s in 1992, is expected to lower to 7.0 Gcal/t-s based on the production of 5.57 million tons/steel in 2002 as judged from the actual results so far due to the effect of production increase.

2.2.2 Comparison of energy unit consumption in the whole steelworks

The unit consumption of energy in SIDEX in 1992 was 8.45 Gcal/t-s (per tonnage of crude steel), and is fairly higher by 2.45 Gcal/t-s than the Japanese 5.0-6.5 Gcal/t-s (average 6.0 Gcal/t-s) in 1992. As Fig. II.2-6 shows, the difference can be analyzed for each division. Approximately 75 % of the difference is caused by the difference of energy unit consumption in the iron-making division and the rolling division, and hence improvement in these divisions is first demanded. While, where the difference is analyzed for energy types, fuel holds about the half of it and electric power does not much. That is, consumption of fuel should be reduced with a top priority.

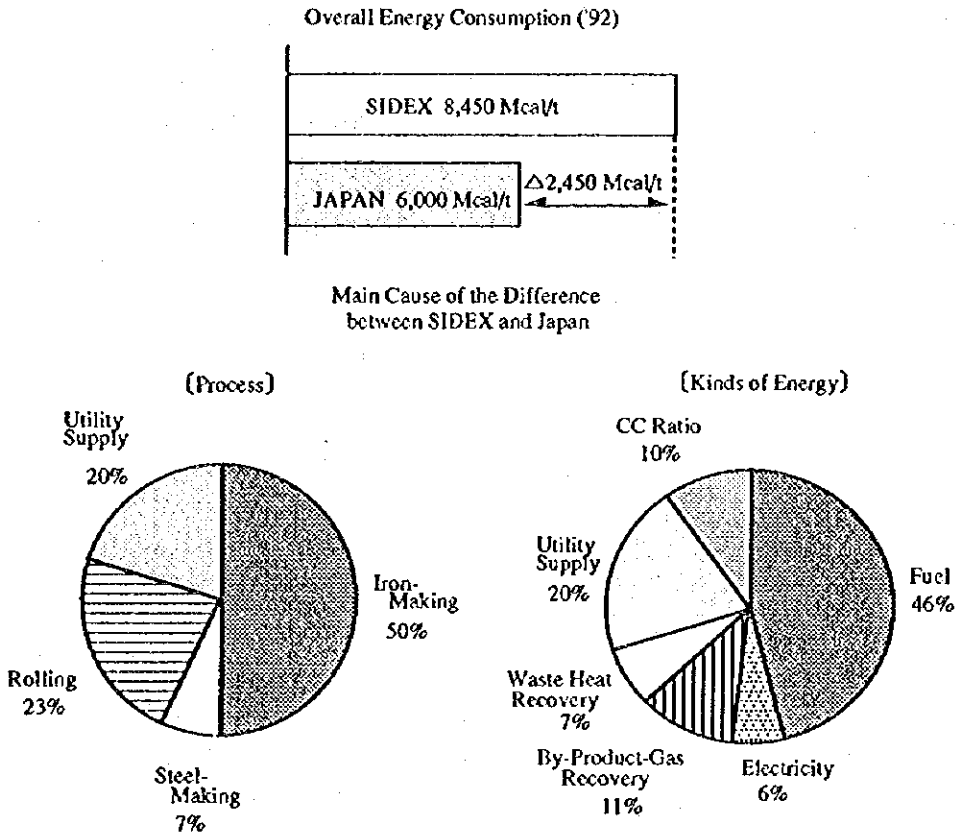


Fig. II.2-6. Comparison of Total Energy Consumption between SIDEX and Japan

2.2.3 Comparison of energy unit consumption between SIDEX and Japan

Table II.2-2 compares the energy unit consumption between SIDEX and Japan. With the exception of higher BFG recovery and lower consumption of electric power in coke plant due to higher BF fuel rate and less dust collectors in coke plants, all the averages of SIDEX are much higher than those of Japan. Therefore, improvement of energy unit consumption of each plant will prove most effective as energy-saving measures. The main reasons for the difference, though some adverse elements that raises the energy unit consumption due to production decrease are included in SIDEX, are as follows:

1) Very high energy unit consumption of each plant, especially in BF and reheating furnaces

2) Low supply efficiency of utilities in the whole steelworks

3) Low recovery rate and quantity of byproduct gas and waste energy

Table II.2-2. Comparison of Energy Unit Consumption in Each Plant

	Item	Unit	SIDEX	Japan
Recovery of Byproduct Gas	COG recovery	Nm^3/t	229	300
	BFG recovery	Nm^3/t	1,753	1,592
Fuel Unit Consumption	Coke oven battery	Mcal/t	669	555
	Sinter ignition furnace	Mcal/t	50	9
	Sinter breeze	kg/t	72	44
	Blast furnace	kg/t	588	516
	Hot stove	Mcal/t	608	433
	Heavy plate mill	Mcal/t	944	335
	Hot strip mill	Mcal/t	1,059	266
Power Unit Consumption	Coke oven battery	kWh/t	32.3	28.0
	Coke chemical plant	kWh/t		18.2
	Sintering plant	kWh/t	47.4	38.1
	Blast furnace	kWh/t	37.1	31.9
	Heavy plate mill	kWh/t	132.4	94.6
	Hot strip mill	kWh/t	193.9	98.3
	Compressed air	kWh/t-s	34.0	16.1
	Oxygen gas	kWh/t-s	72.1	50.1
Power Generation Efficiency		kcal/kWh	4,060	2,658
Steam Consumption	Total	kg/t-s	484	262
Recovery of Waste Heat	CDQ	Mcal/t	150	260

Data from SIDEX in 1992

t = Production in each shop, t-s = Crude steel, Japan = Average value in integrated iron- & steelworks

2.3 Energy-Saving Measures

The SIDEX energy-saving measures, purposing to reduce the purchased natural gas as much as possible, should be taken to realize the followings:

1) Decrease in the energy unit consumption of the plants which greatly consume energy compared with those in Japan, especially BF and reheating furnaces

2) Higher control of energy supply

3) Recovery of unutilized waste energy

2.3.1 Energy saving in each production process

As the comparison of energy unit consumption per process between SIDEX and Japan shows in Table II.2-2, first, the unit consumption of fuels, especially in BF and reheating furnaces, should be decreased, then the unit consumption of electric power and utilities should be decreased.

For the model plants, the measures for energy saving are studied in the following views;

(1) Decrease of heat loss and of energy loss
(2) Improvement of thermal efficiency and of thermal (heat transmission) performance
(3) Collection of waste energy and its efficient use

The details are described later in the section for the model plants.

2.3.2 Higher control of energy supply

In comparison with a Japanese steelworks, SIDEX has a large difference in controlling the energy supply. Stable and efficient supply of energy is the most fundamental measures, in addition to promotion of energy saving in each process, in implementing the measures of energy saving in SIDEX. Fig. II.2-7 shows the concept of measures improved for energy supply in SIDEX. The followings are the principal improved measures, and as to the items (1) and (3) the details are described in Section II. 3.5:

(1) Stable supply of mixed gas
(2) Collection of converter gas
(3) Renovation of blower station for blast furnace
(4) Improvement in the energy demand-supply adjustment function in the energy center

With regard to the above item (2) Collection of converter gas, the energy of converter gas is now partly utilized as a low pressure steam in the waste heat boiler of combustion type. However, comparing to the collection system of converter gas of non-combustion type adopted in Japan at the present, the rate of heat collection for the said energy is prominently low. Therefore, LDG collection facilities and LDG holders should be installed. The capacity of the holder should be 30,000-50,000 Nm^3 considering actual operations in Japan. Besides prediction of LDG generation volume from the operating data of BOF, level control and demand-supply adjustment of gas holders according to operation plans for each production plant are important.

With regard to the above item (4) Improvement in the energy demand-supply adjustment function in the energy center, though the energy is controlled mainly by monitoring the flows and the pressures in principal systems in the energy center, diffusion of fuel gas and similar incidents due to insufficient monitoring the energy flow and for lack of predicting function prevent the stable supply of and the effective use of energy. From now, considering the local conditions of SIDEX, it will be necessary to so study monitoring the energy flow, predicting the energy demand-supply, adjusting the energy demand-supply, and the serial functions of control that the energy center can fully function.

2.3.3 Collection and effective use of waste energy

Compared with Japanese steelworks, some facilities in SIDEX greatly differ in collecting and utilizing the waste energy. The following matters will greatly contribute to energy saving:

1) Installation of TRT on the premise that BF is operated at high pressure

2) Improvement of CDQ operation rate and of its performance

3) Increase in collection of steam by improving the waste heat boilers

These are analyzed later in the chapter mentioning the model plants.

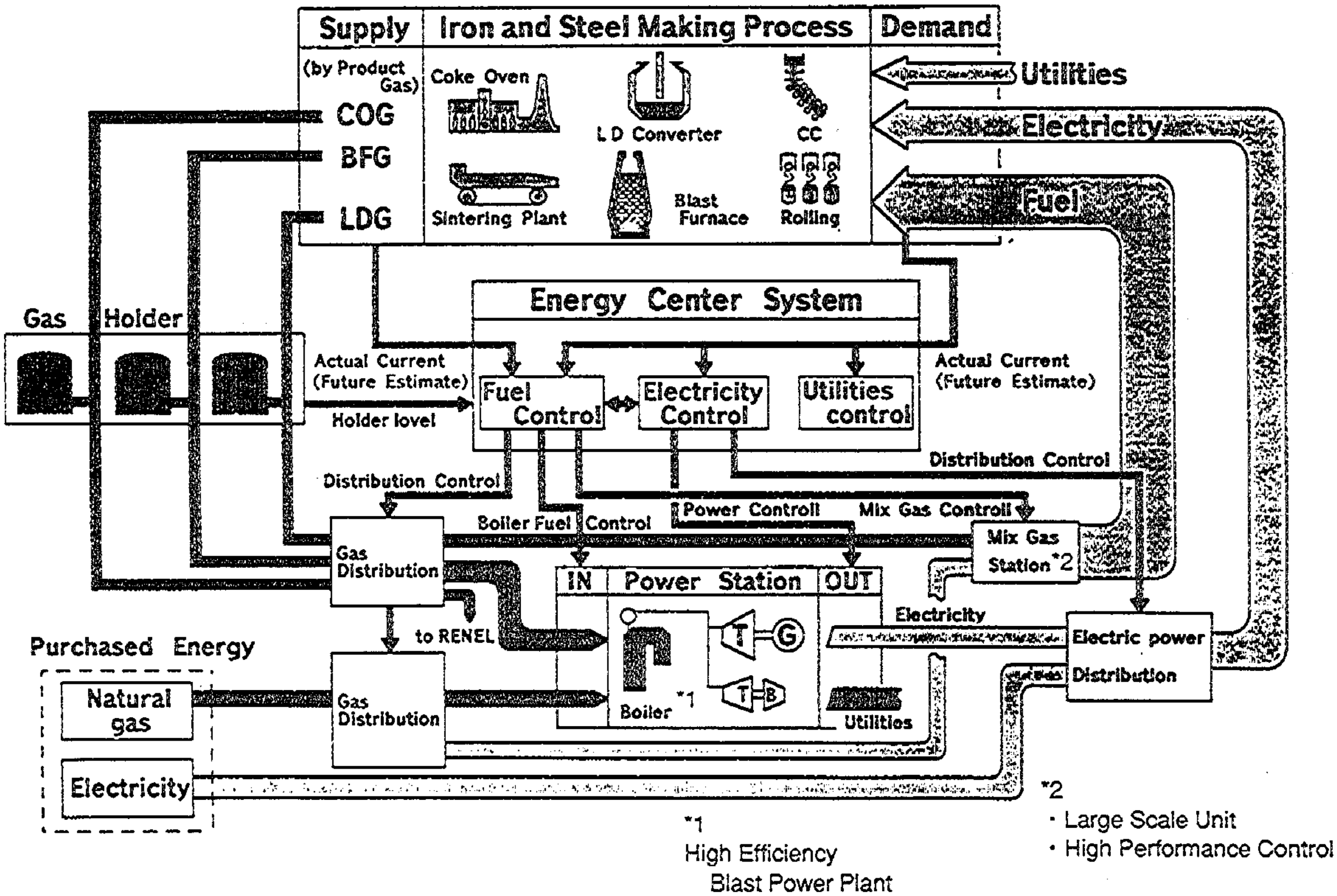


Fig. II.2-7. Image Diagram of Energy Supply and Control System for SIDEX

2.4 Estimated Effects of Energy-Saving Measures

This section summarizes the estimated effects of energy saving based on the results of the site survey. The calculations are based on the production quantity of crude steel in 2002 (see Fig. I.2-2).

2.4.1 Situation before implementation of energy-saving measures

The energy flow before implementation of energy-saving measures is shown in Fig. II.2-8. According to the energy flow, a large volume of natural gas(940 x 10^6 Nm^3/y) is necessary though the energy unit consumption in SIDEX drops to 7 Gcal/t-s, and yet the dependency to petroleum energy shows 35 % which is still high in level.

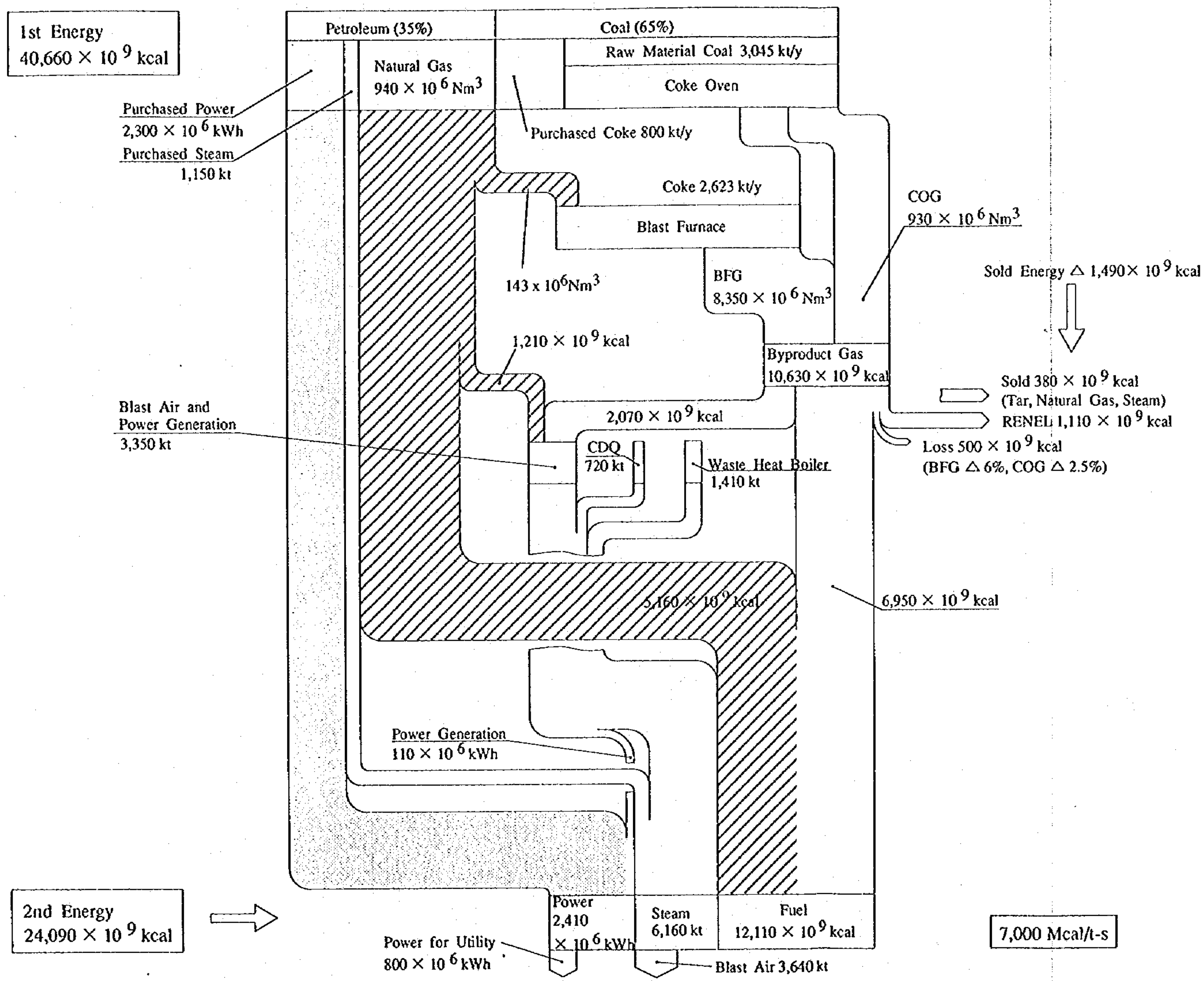


Fig. II.2-8. Energy Flow Chart of SIDEX in 2002 Before Taking Energy Saving Measures

2.4.2 Situation after implementation of energy-saving measures

1) Energy-saving effects on the model plants

As the result of studying the measures for energy saving, in view of reduction of thermal loss and of energy loss, improvement of thermal (heat transmission) performance and recovery of and effective use of waste energy, for the model plants, the principal measures mentioned in Table II.2-3. are examined. The energy to be saved in implementing those measures are counted as Table II.2-4.

Table II.2-3. Main Energy Saving Measures for the Model Plant

The model plant	Main energy saving measures
Coke oven battery (No.5)	· Improvement of combustion control · Automatic-combustion control · replacement with large-scale new CDQ
Sinter (No.6 and 7)	· Improvement of coke breeze burning · Replacement with small-size ignition furnace · Recovery of cooler waste heat
Blast furnace (No.6)	· Improvement of the operational performance · Installation of PCI system · Installation of TRT and recuperators
Reheating furnace (Hot. No.3 RF)	· Installation of high-performance furnace · Installation of recuperators for air and gas · Installation of new control system

Table II.2-4. Energy-Saving Effect on Model Plants

Plant	Item	Unit	Without Energy-Saving Measures	After Energy-Saving Measures
Coke Oven Battery	Fuel rate	Mcal/t	740	670
	CDQ steam recovery	kg/t	199	416
Sintering Plant	Breeze	kg/t	67	58
	COG	Mcal/t	38	10
	Power	kWh/t	40	36
Blast Furnace	Coke rate	kg/t	550	370
	PCI rate	kg/t	0	150
	BFG recovery	Nm^3/t	1,750	1,580
	Blast supply	Nm^3/t	1,500	1,250
	Hot stove fuel	Mcal/t	628	475
	TRT recovery	kWh/t	0	30
Hot Strip Mill	Fuel rate	Mcal/t	830	292

2) When the measures for the model plants are applied to all the related plants

If the measures for the model plants can be applied to all the related plants, the effects of energy saving measures taken by each plant for the whole steelworks will be as shown in Table II.2-5. 990 Mcal per tonnage of crude steel will be saved in total.

Table II.2-5. Energy-Saving Effect on Related Plants

	Energy-Saving Effect
Total of Coke Oven Batteries	150 Mcal/t-s
Total of Sintering Plants	110 Mcal/t-s
Total of Blast Furnaces	510 Mcal/t-s
Total of Reheating Furnaces in Hot Strip Mill	160 Mcal/t-s
Total of Coke Producing Energy by Installation of PCI System	20 Mcal/t-s
Total	990 Mcal/t-s

3) Effects by enhanced control of energy supply

In relation to the effects by the enhanced control of energy supply including improvement in the energy demand-supply adjustment function in the energy center, as described in Section II.2.3., 610 Mcal/t-s in total seems to be saved. (See Table II.2-6.) For LDG recovery the values are only references.

Table II.2-6. Energy-Saving Effect outside of Model Plants

	Without Energy-Saving Measures	After Energy-Saving Measures	Effect
Reduction of Gas Bleeding	5 %	0.5 %	80 Mcal/t-s
Improvement of Blast Blower Plant	0.12 kWh/Nm^3	0.07 kWh/Nm^3	350 Mcal/t-s
LDG Recovery (for reference)	0	90 Nm^3/t	180 Mcal/t-s
Total			610 Mcal/t-s

4) Presumption of increased energy by implementation of environmental measures

Providing that the measures for energy saving and for environment are practically implemented, electric power, energy for utilities, and so on will be consumed because of installation of devices. Table II.2-7. shows the increased energy due to implementation of those measures, and 70 Mcal/t-s in total seems to increase as the result of installation of dust collectors, utilities for an energy-saving device, such as PCI, and reduction of steam (converter, heating furnace).

Table II.2-7. Presumption of increased energy

Item	Equipment	Increased energy
Environmental measures	Installation of dust collector	15 Mcal/t-s
Supplementary measures for energy saving	Utilities for PCI device	5 Mcal/t-s
Decrease of steam produced by collecting waste heat	LD boiler, Hot rolling boiler(?)	50 Mcal/t-s
Total		70 Mcal/t-s

5) Summary of expected effects

The energy-saving measures recommended so far will decrease the SIDEX's energy unit consumption for crude steel by 21% from 7.0 Gcal/t-s to 5.5 Gcal/t-s. The average crude steel energy unit consumption in the Japanese BF mills in 1992 was 6.0 Gcal/t-s, and this corresponds to 5.35 Gcal/t-s when adjusted according to the production balance in SIDEX, showing a fairly high level in 2002. And, in spite of large increase of production, the purchased volume of natural gas is expected to decrease by 81% from 940 MNm^3/y (before execution of energy-saving measures) to 171 MNm^3/y, which will bring about stable operation not affected by the supply condition of natural gas. Purchased electric power, on the other hand, is expected to decrease from 2,300 GWh/y to 2,170 GWh/y. Together with future further strengthening of electric power saving measures such as prevention of idling at operational shutdown, rotating speed control according to operational conditions, and improved efficiency of rotary machines, further energy saving is expected. See Fig. II.2-9 and Table II.2-8.

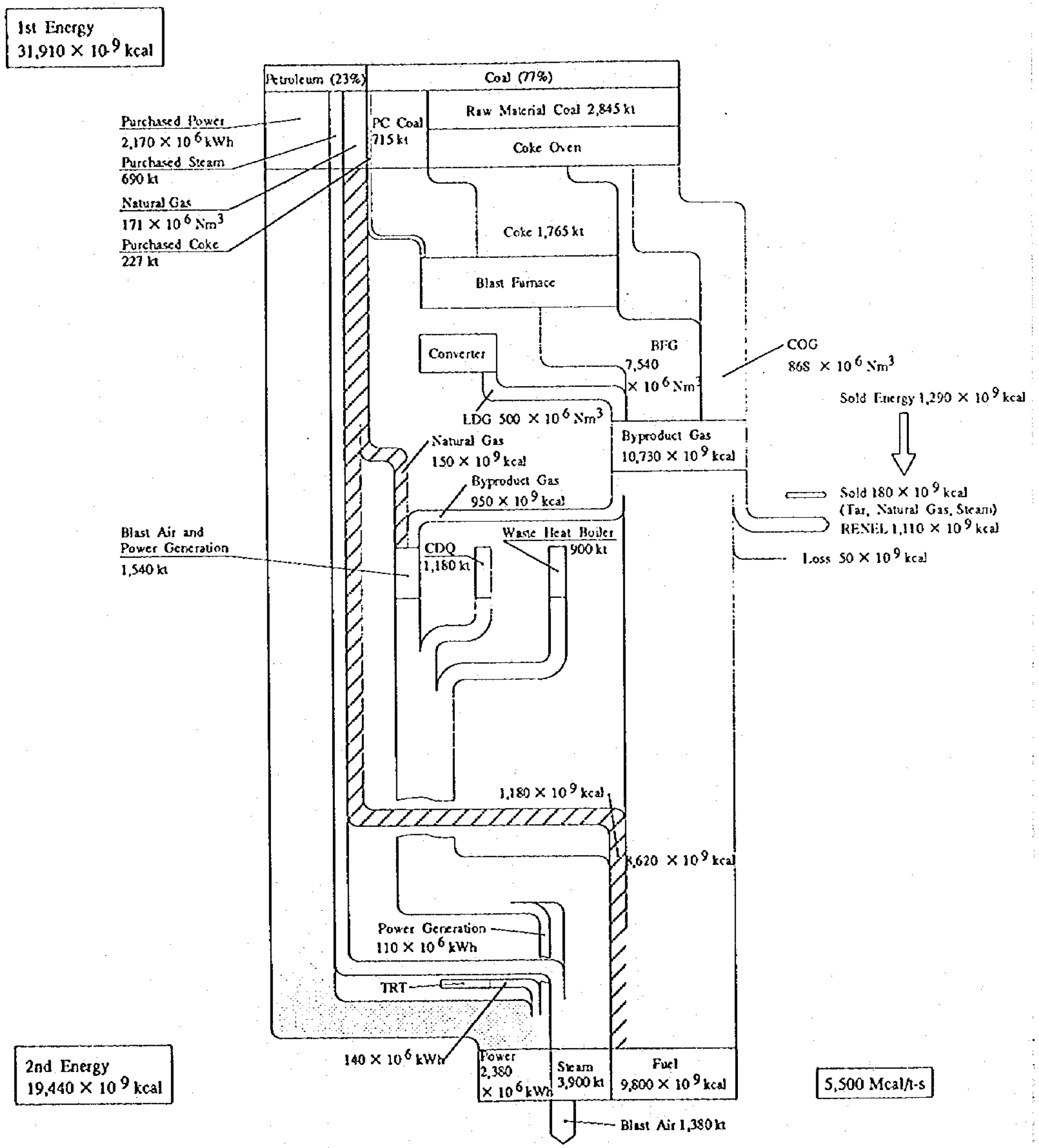


Fig. II.2-9. Energy Flow Chart in 2002 After Taking Energy Saving Measures

Table II.2-8. Resources of Primary Energy of SIDEX in 2002

				Energy Saving	
			Unit	Before	After
Purchased Energy	Coal	Coking Pit Coal	kt/y	3,045	2,845
		Purchased Coke	kt/y	800	31(*)
		PC Coal	kt/y	0	715
		Sub Total	Tcal/y	26,355	24,615
	Petroleum	Natural Gas	Mm3/y	940	171
		Purchased Power	GWh/y	2,300	2,170
		Others	Tcal/y	1,125	675
		Sub Total	Tcal/y	14,328	7,369
Total			Tcal/y	40,683	31,984
Sold Energy			Tcal/y	1,490	1,290
Net Consumption of Energy			Tcal/y	39,193	30,694
Crude Steel Production			kt-s/y	5,570	5,570
Energy Unit Rate per Crude Steel			Gcal/t-s	7.03	5.51

(*) This value = Purchased coke - Sold coke

3. SURVEY AND STUDY OF SELECTED FACILITIES (MODEL PLANTS)

3.1 Coke Plant

3.1.1 Outline of the facilities and present status of the energy-saving facilities

The coke plants are outlined in Table II.3-1.

1) Coke oven batteries (COB)

Nos. 1 to 4 COBs and Nos. 5 to 6 COBs are installed in the first area and Nos. 7 to 8 COBs are installed in the second area. In 1992, 316 ovens of the five COBs in the first area were in operation. Though all the COBs in the second area were out of operation in 1993, hot repair of No.8 COB was completed and operated on June, 1994.

2) Coke dry quenching facility (CDQ)

As energy-saving facilities, the following CDQs are installed and recover medium-pressure steam.

- No.1 CDQ for Nos. 1 to 4 COBs
- No.2 CDQ for Nos. 5 to 6 COBs
- No.3 CDQ for No.7 COB
- No.4 CDQ for No.8 COB

Against failure of CDQ, a wet quenching facility is installed for each CDQ. Presently, Nos. 1, 2 and 4 CDQs are in operation.

3) Model plants

Main specification of the model plants, No.5 COB and No.2 CDQ, is shown in Table II.3-2.

Table II.3-1. COKE PLANTS IN SIDEX

(Note: ░ model plant)

Plant	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6	No. 7	No. 8
Commissioning (restarting)	1973 ('83)	1973 ('89)	1975 (-)	1974 ('92)	1976 ('85)	1977 ('87)	1982 (-)	1982 ('94)
Dimensions (HxLxW) (m)	3.8 x 12.58 x 0.46				5.5 x 14.2 x 0.41		7.0 x 15.16 x 0.41	
No. of ovens	62	62	62	62	65	65	65	65
Type & Name of designer	PTU S7E (Single type) KOKSOPROJECT				PVR 30.3 (Single) GIPROKOKS		PVR 416(Compound) GIPROKOKS	
Production cap. (1000 t/y)*1	330	330	330	330	600	600	850	850
Operation status*2	◎	◎	△	◎	◎	◎	×	○
Corresponding CDQ PLANT	○ No. 1 CDQ				○ No. 2 CDQ		○ No. 3 CDQ	○ No. 4 CDQ
Corresponding Chem. plant	○ No. 1 C.P. (Chemical plant)				○ No. 2 C.P.		○ No.3 C.P.	○ No.4 C.P.

*1 Coke production capacity (including 5 % moisture)

*2 ◎: in operation ○: waiting for start after completion of hot repair
△: stoppage for replacement ×:stoppage

Table II.3-2. Specification of Model Plants

1.	No .5 Coke Oven Battery	
	• Type	PVR -Ghiprokoks 30.3 type (65 ovens)
		Single type (rich gas only) with 2 ascension pipes/oven
	• Dimensions per oven	5,500 H x 14,200 L x 410 W (effective volume: 31.6 m3)
	• Commissioning year	Sept.1976 (Latest overhaul 1985)
	• Production capacity (design base)	600,000 t/y
		(size of coke > 25mm, including 5% moisture)
	• Heating system	Brick (Silica/Fire-Clay), heating flues (30)
	• Fuel	COG (4,000 kcal/Nm3)
	• Stack height (m)	100
	• Charging machine, 3 sets	Type (Ghiprokoks-IPROMET), Bin (30.6 t)
		Ascension pipe cleaning (Mechanically operated)
		103 ovens per day
	• Coke pusher, 2 sets	Type (Ghiprokoks-IPROMET)
		Position check-up (Operator visuality)
		105 ovens per day
	• Coke guide & door extracting car, 2 sets	Equipped with dedusting cyclons
		105 ovens per day
	• Wet quenching car, 2 sets	
2.	No. 2 CDQ (Coke Dry Quenching Facility)	
	• Number	5 (3 operating + 2 stand-by)
	• Type	GHIPROKOKS
	• Quenching capacity per set (t/h)	46-50
	• Steam production per set (t/h)	25
	• Steam pressure (atm)	35-40
	• Steam temperature (°C)	380-420

3.1.2 Operational status

1) The procurement status of coking coal and the production of coke for these three years are shown in Fig. II.3-1. More than 90% of the required coal is imported. This unstable balance is one of reasons that affect the operation rate of COBs.

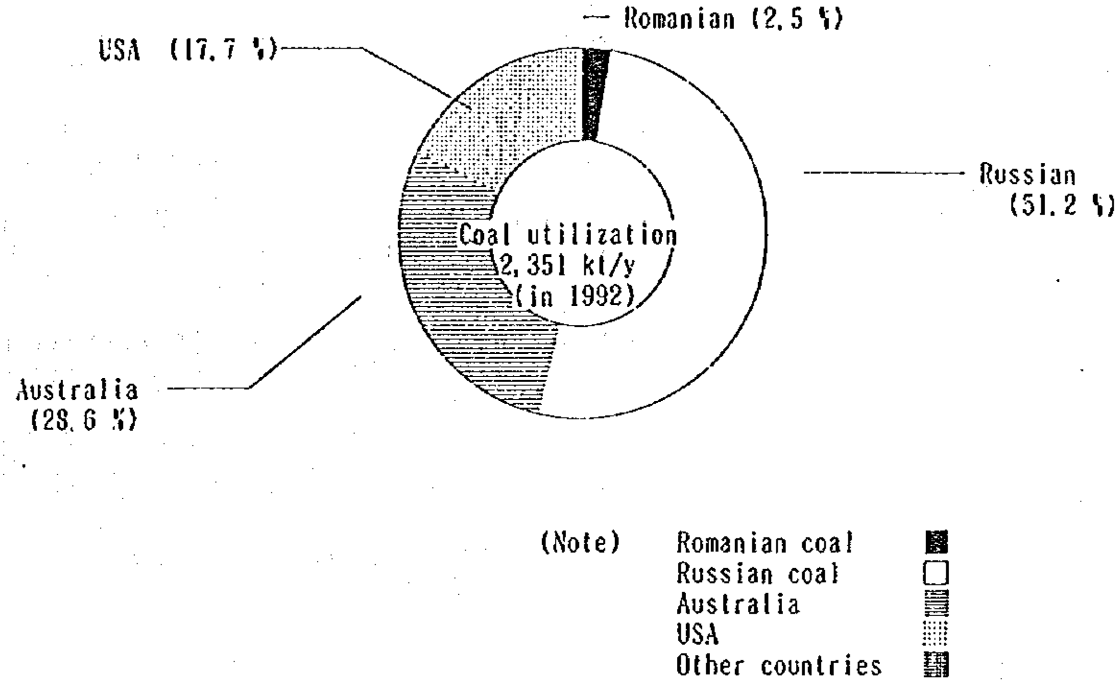
2) Unstable consumption in the downstream, and repair of coal charging cars/pushing cars/guide cars/quenching cars at intervals of a few days adds to the unstable production.

3) The average life of COB is about 10 years, compared with 35 years in Japan. That is, in the short cycle of a quarter of the Japanese life, bricks including those in the regenerator and metal pieces are overhauled, maybe because of the difference in the design, material, and operating conditions. First of all, measures for enhancing the control of operation and maintenance should be taken.

3.1.3 Production balance

Fig. II.3-2 shows the production in 1992 and 2002 as the basis for establishing the energy-saving measures and the estimated production after energy-saving measures. In 2002, the production of coke will increase from the present to 2.121 million t/y. But SIDEX can supply to the amount by the increase of operation rate of the large COBs (Nos. 5-7 COBs). The small Nos. 1 to 4 COBs, not good in thermal efficiency and in air pollution protection, must be integrated into the large Nos. 5 to 7 COBs, and Nos. 1 to 4 COBs should be shut down.

(1) Experience record of coal utilization in 1992



(2) Reference: coal utilization (from 1990 to 1992)

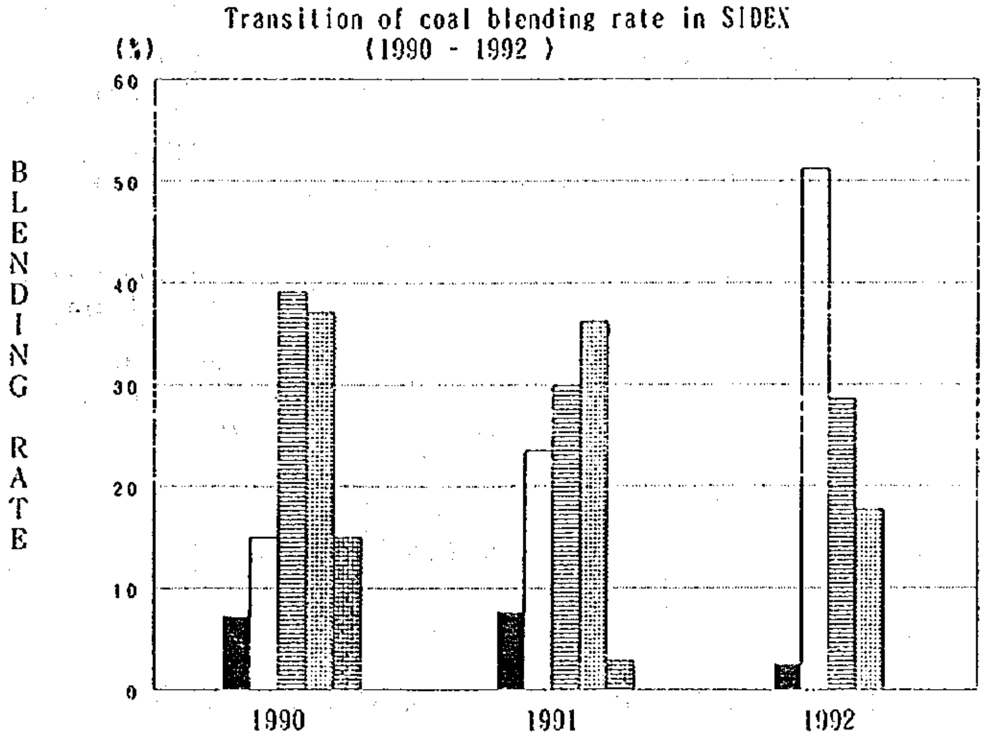
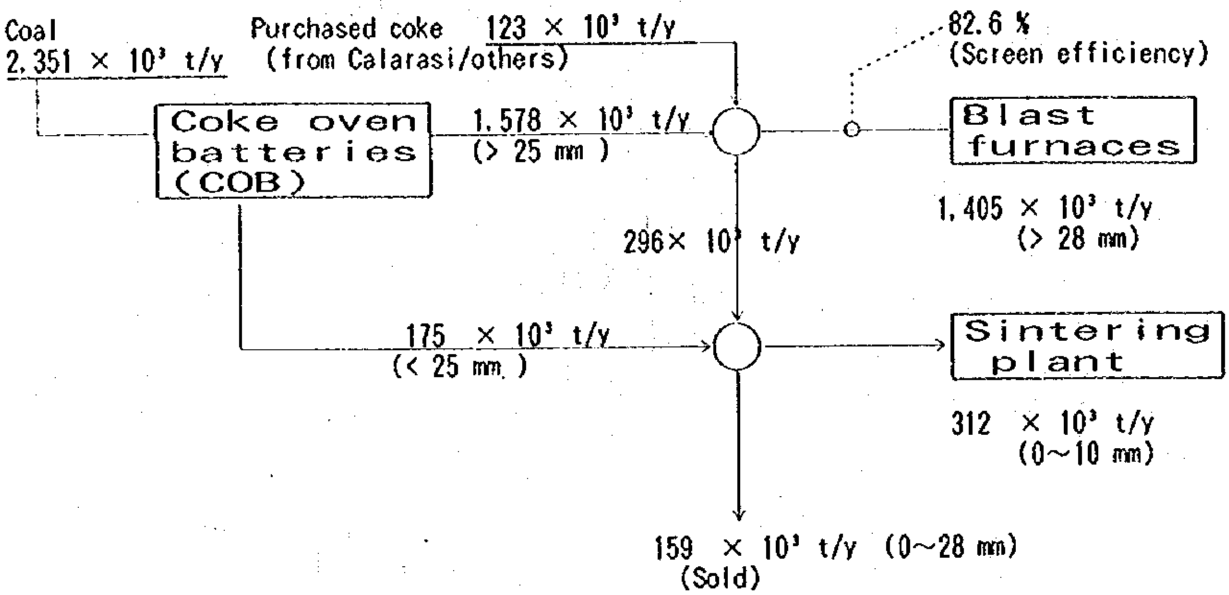
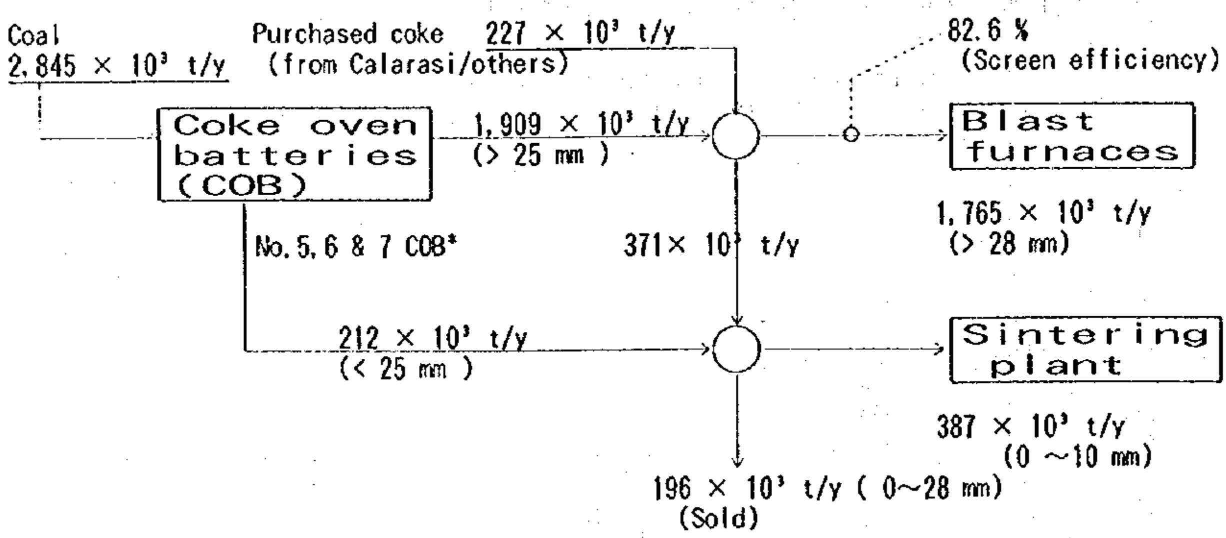


Fig. II.3-1. Experience of coal utilization in 1992

YEAR 1992



YEAR 2002



* SIDEX can meet the coke demand by three COBs(No.5,6 & 7 COB).

Fig. II.3-2. Production Balance

3.1.4 Analysis of the problems found in Model Plant

1) Heat balance and energy recovery

Table II.3-3 shows the heat balance in No.5 COB, Table II.3-4 compares SIDEX's byproducts in coke plant with those of a Japanese one, and Fig. II.3-3 compares heat loss between SIDEX and Japan.

As seen from the above, the fuel unit consumption in No.5 COB is 662 Mcal/t, higher than the Japanese 592 Mcal/t by about 10%. Though there are two standby CDQ, the recovered heat in CDQ is about 60% of the Japanese (no standby in this Japan).

Note: SIDEX's data shows that the COG calorie is abnormally as low as 3,500-3,700 kcal/Nm^3. In the No.5 COB, the coke oven door has just been replaced by a new self-sealing type, allowing almost no leakage of gas from the door or entry of air. Correspondingly, the COG calorie could actually be higher by 20 to 30%. In the second site survey, COG calorie was analyzed by use of a gas-chromatography, and, as the result, COG calorie is decided to 4,350-4,400 kcal/Nm^3.

2) Energy-saving themes

(1) Coke oven temperature

Presently, the coke oven temperature has to be set high as shown in Fig. II.3-4 maybe because of the following reasons:

- Capacity of some ovens has lowered due to nozzle clogging (by BTX, etc.), maladjustment of gas flow rate, damage to bricks, etc., and the oven temperature is raised to make the oven operate sufficiently.

• Flow rate control of COG according to the flue temperature of oven is not sufficiently done. Therefore, when the flow rate is adjusted to secure the enough temperature at low calorie, this raises the coke oven temperature excessively at high calorie. Too high temperature of coke oven not only consumes fuel in vain but also increases the radiation heat loss.

(2) Facility troubles

Many facility-related troubles, which disturbs efficient, are caused unstable operation, and this also explains the high heat loss such as radiation heat.

(3) Combustion air ratio

The combustion air ratio is as high as 1.35 in SIDEX, compared with 1.28 in Japan. Also, measurement before a chimney shows that CO is 0.1-0.2%, which shows incomplete combustion. This indicates a high possibility of the COG leakage from the coking chamber to the combustion chamber because of brick damages, unbalanced combustion in each oven and lack of air rate control to follow up the COG calorie fluctuation.

(4) Recovery of CDQ steam

The recovery of CDQ steam is as low as 202-258 kg/t-coal, compared with the 376-411 kg/t-coal in Japan, possibly because of quite degraded operation rate due to a long time of repair caused by degradation of the facilities in 20 years since commissioning. As seen in Fig. II.3-5, the operation rate in SIDEX which has two standby boilers is lower than that in a Japanese plant which has no standby boilers. And as Fig. II.3-6 shows, boiler troubles are most frequent, and this may be because of the boiler structure. Coke breeze is apt to accumulate and causes wear or clogging of boiler tubes.

(5) Fuel

Presently, COG is the only fuel. If mixed gas (3,800-4,000 kcal/Nm^3) can be used instead, the remaining COG can be used in the reheating furnaces, etc., leading to a decrease of natural gas consumption.

Table II.3-3. Heat Balance for No.5 Coke Oven Battery

	Items	Remarks	Mcal/t-coal (%)
INPUT	Fuel latent heat	Flow rate 150.7 Nm³/t-coal Calorie 4,250 kcal/Nm³	636.6 (96.2)
	Fuel sensible heat	Fuel temp. 60 ℃	3.0 (0.4)
	Coal sensible heat	Coal temp. 26 ℃	8.3 (1.3)
	Combustion air sensible heat	Air temp. 51 ℃ Flow rate 865.2 Nm³/t-coal (excess air rate 1.35)	13.7 (2.1)
	Total		661.6 (100.0)
OUTPUT	Coke sensible heat	Coke yield 74.73 % Coke temp. 1030 ℃	274.0 (41.4)
	COG sensible heat	COG yield 305.4 Nm³/t-coal COG temp. 410 ℃	133.5 (20.2)
	Chemicals sensible heat	Chemicals yield 5.12 % Temp. 410 ℃	13.1 (2.0)
	Waste gas sensible heat	Waste gas temp. 288 ℃ Flow rate 797.5 Nm³/t-coal (excess air ratio 1.35)	95.4 (14.4)
	Heat loss & others		145.6 (22.0)
	Total		661.6 (100.0)

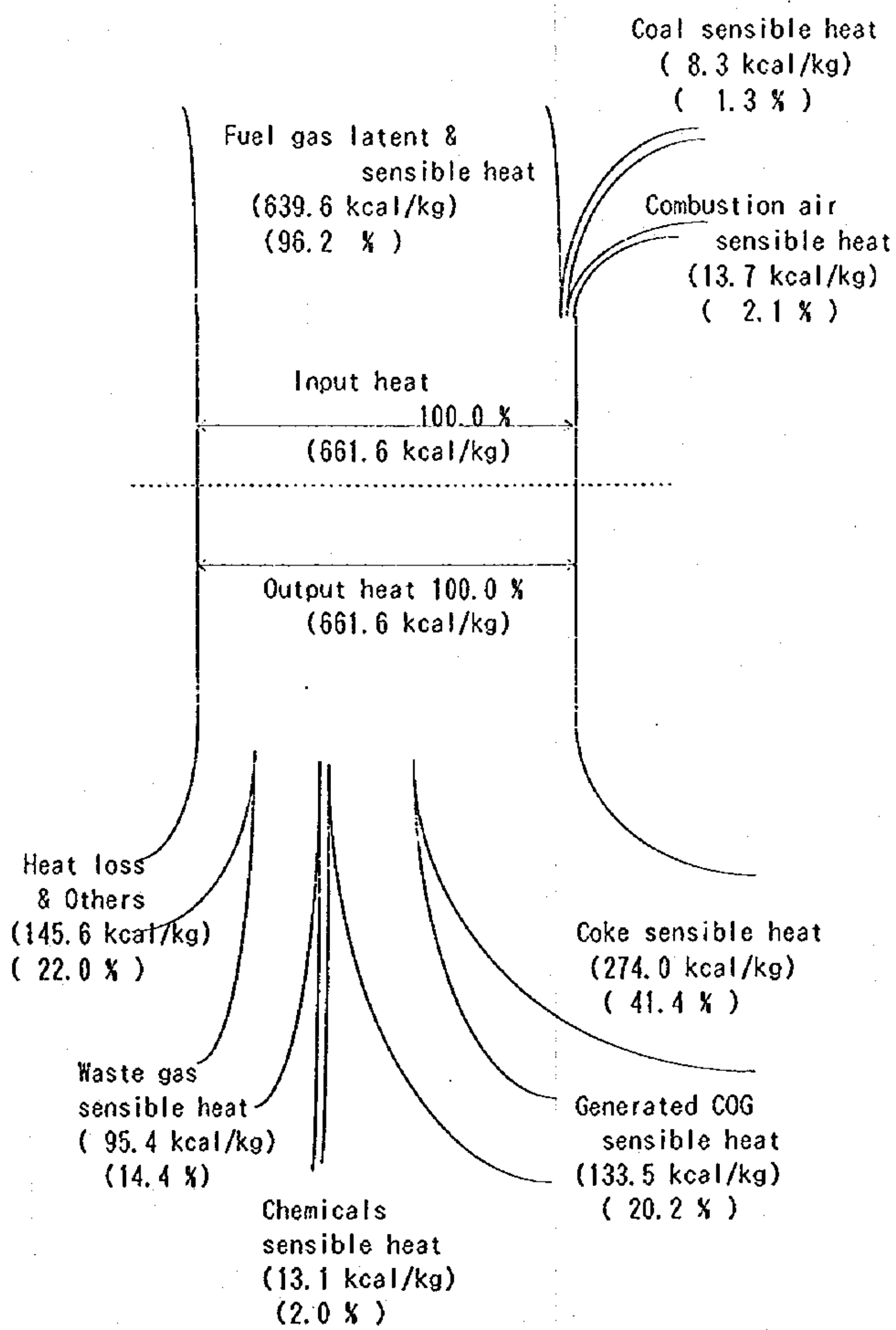


Table II. 3-4. Comparison between SIDEX's Coke Chemical Plant and Japanese One

Item		Unit	SIDEX			Kakogawa	
			'90	'91	'92	'92	'93
YIELD	Coke except the very small size	%	76.6	75.7	71.5	75.4	76.4
			Av. 74.57 %				
	COG(generated state) [calories] (4,800 kcal base)	Nm^3/t [kcal/ Nm^3] (Nm^3/t)	305.4 [3,579] (228.9)	303.5 [3,579] (227.4)	305.4 [3,579] (228.9)	322.6 [4,377] (294.2)	327.3 [4,289] (292.4)
	Recovery steam from CDQ (No. 1 & 2 CDQ 平均)	kg/t-coke (kg/t-coal)	371 (258)	371 (254)	316 (202)	498 (376)	538 (411)
	Tar(with 5% mois.)	%	3.49	3.82	3.35	3.37	3.13
	Light oil(BTX)	%	0.85	1.05	0.84	1.14	1.11
	NH_3 in $(NH_4)_2SO_4$	%	0.02	0.01	0.02	—	—
	NH_3 in NH_3 aqu.	%	0.12	0.19	0.15	—	—
	Liq. NH_3(at 100%)	%	—	—	—	0.23	0.22
	S in H_2SO_4	%	—	—	—	0.13	0.12
	Total chem. yield	%	4.48	5.07	4.36	4.87	4.57

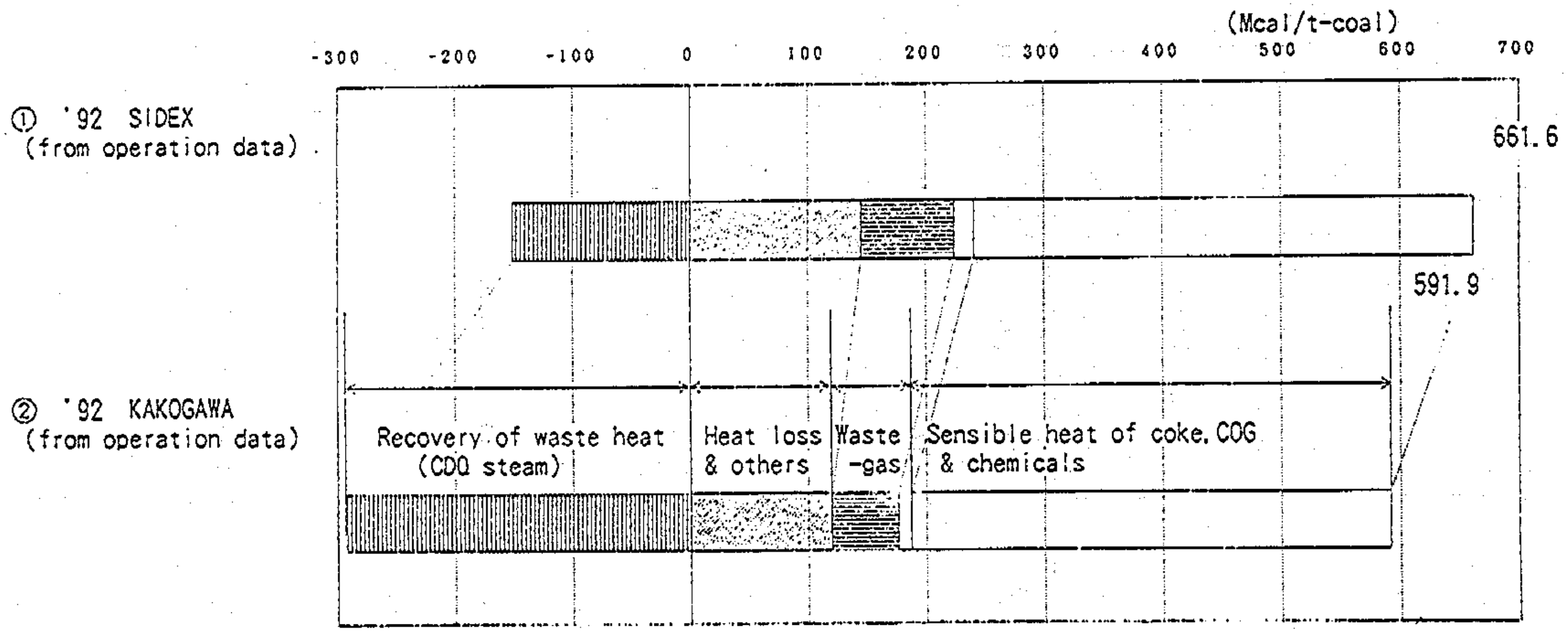


Fig. II.3-3. Comparison of Heat Loss

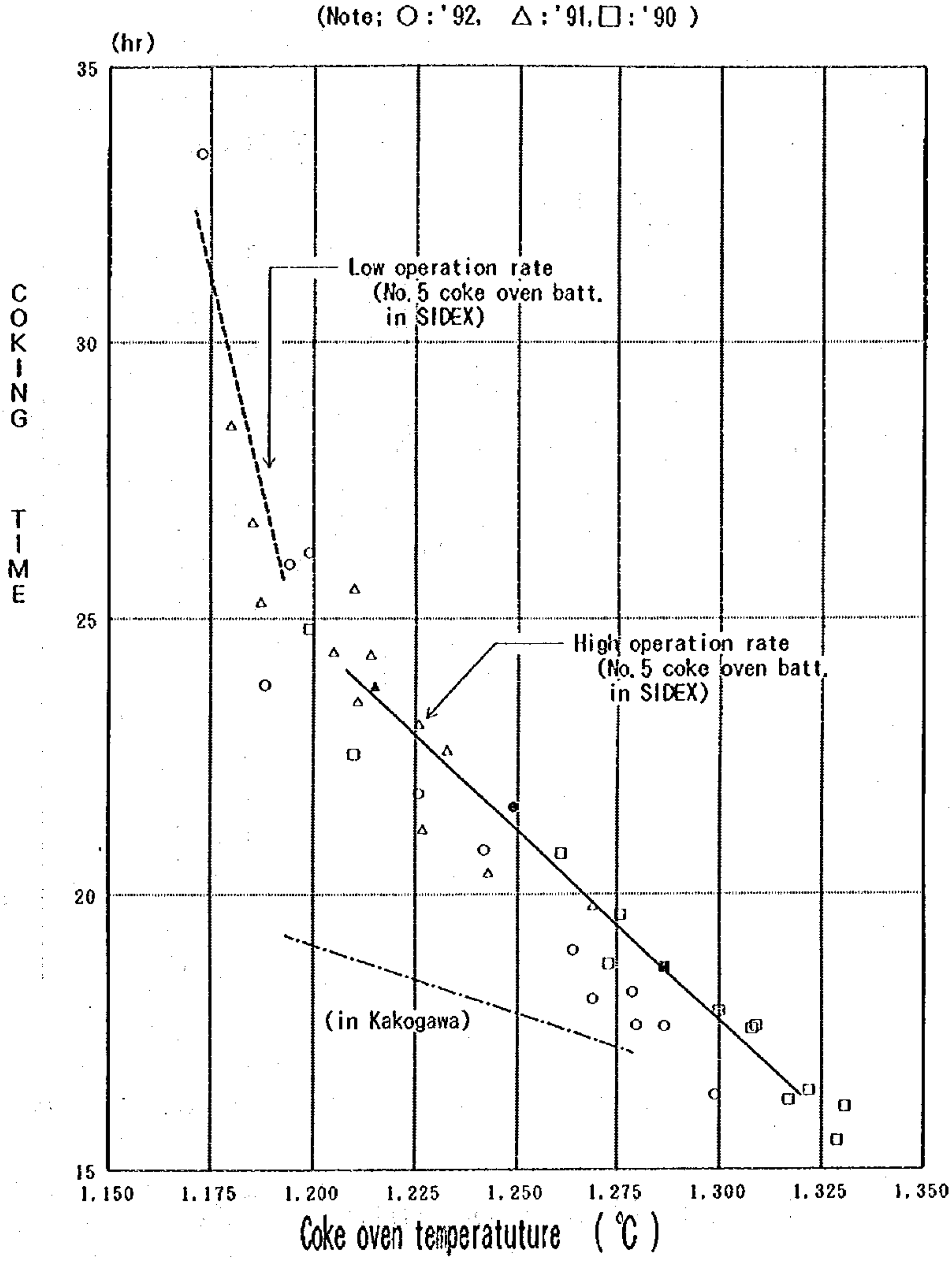


Fig. II.3-4. Relation between Coking Time & Coke Oven Temp.

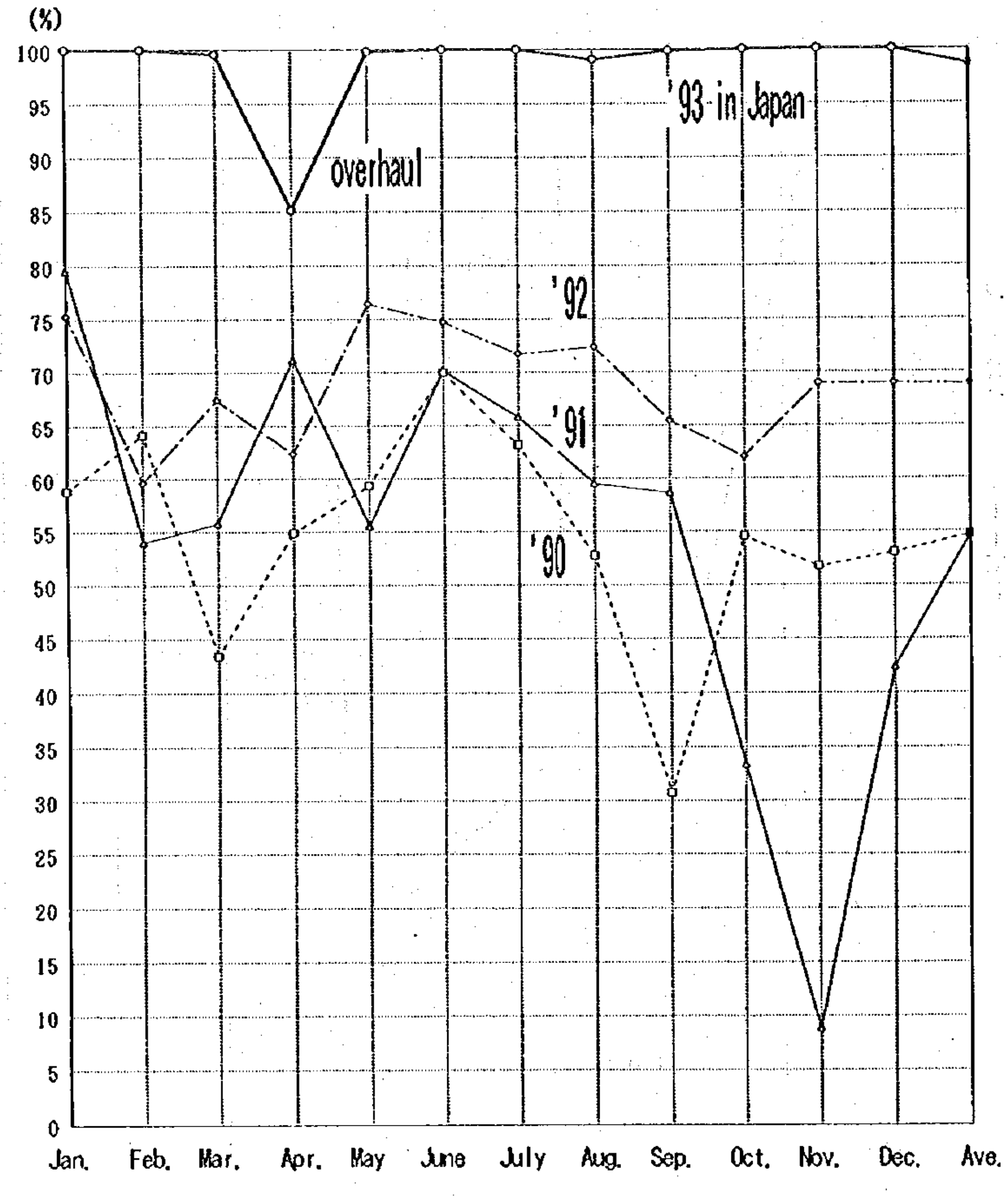
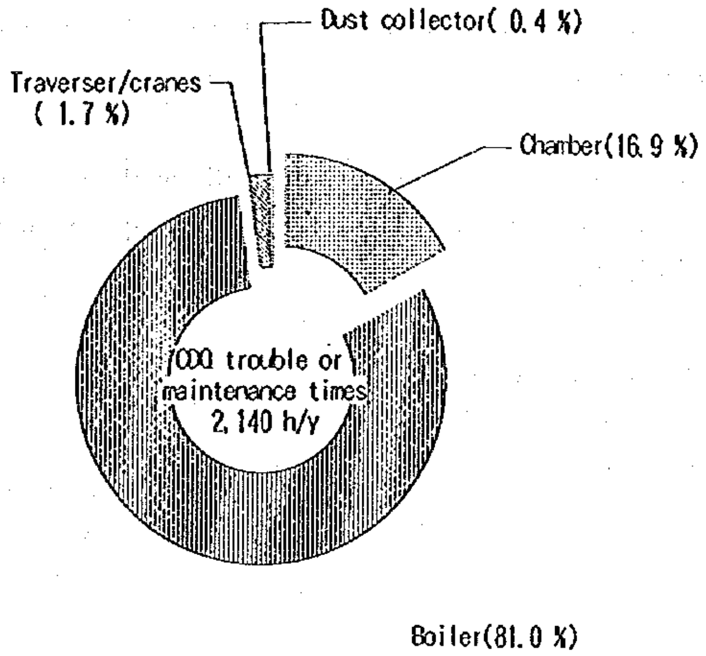


Fig. II.3-5. Operation rate of CDQ



Div.	Facility	Major troubles
COQ	Chamber	Discharging equipment : gate blocking mulfunction
	Boiler	Breaking of boiling system pipes
	Traverser/cranes	Brake's coil
	Dust collectors	Breaking of multiclone battery

Fig. II.3-6. Equipment maintenance in 1992

3.1.5 Measures and estimated effects

This section shows the energy-saving measures for the model plants and their estimated effects.

Conclusively, the fuel unit consumption will be decreased by 70 Mcal/t-coal and recovery of steam by CDQ will increase by 363 k.t/y (Nos. 5 & 6 COBs) in the year 2002.

Please refer to the following pages.

3.1.5.1 Energy-saving measures and estimated effects

Purposes		Measures	Details of Measures	Estimated Effects in 2002
1. To improve the operation (including enhanced control of operation and maintenance)	To decrease oven set temperature by improving the combustion control	To identify abnormal combustion oven and to adjust it	To improve abnormality in horizontal temperature distribution: • Adjustment of flow rate of fuel and air in each flue • Decrease of COG leakage and suction of air by repairing damaged refractory and correcting clogged nozzle by air scarfing	• Decrease of heat consumption: 30 Mcal/t-coal • Decrease of COG consumption: 5,900 x 10^3 Nm^3/y
	To decrease fuel gas consumption by improving operation and maintenance practices	• To decrease damage to oven bricks and failure of coke oven machinery • To optimize operating conditions	• To extend the repair interval of bricks by suitable repair method • To decrease unexpected failure by periodic repair or improved repair method for coke oven machinery and to improve adjustment method for COB at failure To improve heat consumption during less-frequent pushing operation	• Decrease of heat consumption: 5 Mcal/t-coal • Decrease of COG consumption: 1,000 x 10^3 Nm^3/y
2. To modify or improve the equipment (including auxiliary equipment)	To increase BTX recovery rate	To install continuous gas chromatography for measuring BTX	To improve operation of BTX recovery equipment with instrumentation	Increase of BTX yield: 3,500 t/y
	To change fuel gas from COG to mixed gas of BFG and COG	To install BFG piping and gas mixer	To decrease nozzle clogging by adjusting the calorie of mixed gas (3,800-4,000 kcal/Nm^3), which will also decrease NOx in waste gas	• Decrease of heat consumption: 3.5 Mcal/t-coal • Decrease of COG consumption: 3,800 x 10^3 Nm^3/y • Demand of BFG: 18.7 x 10^6 Nm^3/y

Purposes		Measures	Details of Measures	Estimated Effects in 2002
3. To add new functions or to renew the equipment	• To decrease COG consumption by semi-automatic combustion control	• To install combustion control system with continuous instrumentation • To process data using personal computer	• Control of input heat by Wobbe index meter • Automatic control of air ratio by O2 meter and dust meter • Operational data processing by personal computer: - Output of guidance for fuel flow rate and combustion air ratio through relationship between temperature and productivity - Output of guidance for temperature distribution, coking time, and abnormal oven	• Decrease of heat consumption: 31.5 Mcal/t-coal • Decrease of COG consumption: $6,200 \times 10^3$ Nm^3/y
	• To decrease heat loss by fortified combustion control of COB	To conduct improved combustion control and trend control by installation of operation control monitor	To improve combustion control by installation of Wobbe index meter, and waste gas analyzers (O2 meter, CO meter, dust meter): • Improved control of relation between input heat and oven temperature • Decrease of excess air ratio and CO content of waste gas	
	To increase recovery of steam by overall revamping of CDQ	To replace by high performance CDQ	Introduction of the latest technology: • CDQ capacity: 145 t/h x 1 • New arrangement of boiler tube for prevention of abrasion • Coke discharging system • Automatic control system for increasing heat recovery	• Increase of steam recovery: 363 kt/y • Replaced amount by cheap coal 58 kt/y*

* Note: As a result by overall revamping of CDQ, coke quality will be improved.
A part of strong coking coal is replaced to cheap and weak coking coal.

3.1.5.2 Summary of estimated effects (for No.5 Coke oven battery)

	Present (No.5 COB: 627.0 x 10^3 t-dry coal)	In 2002 (No.5 COB: 835.0 x 10^3 t-dry coal)	
	Present (No.1-4 & 5-6 COB)	Before the improvement	After the improvement* (No.5-6 & 7 COB with PCI system)
• Heat consumption of No.5 COB (Mcal/t-coal) • Steam recovery of No.2 CDQ (kg/t-coal: 775 kcal/kg)	650 198.7*	740 198.7*	670 416.1**
• COG consumption (x10^6 Nm^3/y) • Demand of BFG (10^6 Nm^3/y) • BTX recovery (t/y) • CDQ steam recovery (x10^3 t/y) (Nos. 5 & 6 COBs)	95.9 0 - 249.2	145.4 0 - 331.8	128.5 (△16.9) 18.7 (+18.7) (+3,500) 694.9 (+363.1)

* This value is equivalent to only No.2 CDQ, and operation rate of the CDQ is 60%.

** This value is equivalent to one of only No.2 CDQ, and operation rate of the CDQ is 95%.

*Details

		Improving operations	Improving facilities	Installation of new facilities/equipment
To decrease the heat consumption	Contents	Improving control of combustion & operation	• Changing fuel gas from COG to a COG-BFG mixture • Improvement of BTX recovery	• Automatic combustion control • Improving heat management with instrumentation
	Estimated effects	• Decrease of heat consumption 35 Mcal/t-coal • COG consumption -6,900 x10^3 Nm^3/y • BFG demand ±0 x10^3 Nm^3/y • BTX recovery 0 t/y	3.5 Mcal/t-coa -3,800 x10^3 Nm^3/y +18,700 x10^3 Nm^3/y +3,500 t/y	31.5 Mcal/t-coa -6,200 x10^3 Nm^3/y ±0 x10^3 Nm^3/y 0 t/y
To increase steam recovery	Contents			Installation of new CDQ: 145 t/h x 1 set
	Estimated effects			Increase of steam recovery: (Nos. 5 & 6 COBs) 694,900 t (+363,100 t)
Decrease of coal cost	Replaced amount of coal			As the result of revamping CDQ: 58,000 t/y

3.2 Sintering Plant

3.2.1 Outline of the facilities and present status of the energy-saving facilities

The main specification of the No.7 sintering plant, selected as the model plant, are shown in Table II.3-5. Though the main blower has been modified to a low suction pressure type to meet the reduced production, the charging device and the ignition furnace, which have been greatly improved for energy saving in Japan, are of the same design at construction and need improvement. As waste heat recovery, No.6 sintering plant is equipped with simplified cooler waste heat recovery device but no energy-saving facilities for No.7 sintering plant.

Note: Of the Nos.6 and 7 sintering plants that are in the scope of the study, the No.6 sintering plant was shut down and to be shut down also in 1994, and so its operational data could not be collected. Accordingly, the study team concentrated on the No.7 sintering plant for the study of energy-saving and environmental protection measures. For the No.6 sintering plant, conceptual design for the cooler waste heat recovery device, the only big difference from the No.7 sintering plant, will be given.

3.2.2 Operational status

1) Yearly actual production quantity (Table II.3-6) For maintenance and modification of the facilities, each sintering plant is given a long, scheduled shutdown at intervals of about seven years. The shutdown period is about 1.5 months for Nos.1 to 4 sintering plants, about 3 months for Nos.5 to 6, and about 6 to 12 months for No.7.

2) Comparison of operating parameters between SIDEX and Japan in 1992 (Table II.3-7)

The productivity, operational availability, and product yield in SIDEX are lower than those of Japan and the consumption of coke breeze and COG in SIDEX are higher than those in Japan, suggesting the need of improvement.

3) Unscheduled shutdowns of No.7 sintering plant for one year (Table II.3-8)

Unscheduled shutdowns due to unbalance of production between BF and sintering plant occurred for 82 hours/month at the frequency of 10 times a month, leading to the decrease of operational availability by 11 %. Unscheduled shutdowns due to facility troubles occurred for 29 hours/month at the frequency of 9 times a month. These unscheduled shutdowns possibly cause energy loss during operational stop or startup.

4) Quality of sintered ore in 1993(Table II.3-9)

Large fluctuation of chemical composition due to change of mixing ratio of raw materials is seen. Since the consumption of coke breeze is mostly constant in spite of fluctuation of chemical composition or productivity, the strength, reducibility, and yield of sintered ore seem to be fluctuating.

Table II.3-5. Main Specification of Sintering Plant

Equipment	Item	No. 7 Plant
Sintering machine	Sintering area Sprocket & span Pallet Grate bar Strand motor Thermal elongation absorption	$5^{W} \times 100^{L} =$ 500m^2 126.75 m $550^{H} \times 1500^{L} \times 179$ pieces $(46^{W} - 40^{W}) \times 490^{L}$ 310 pieces/pallet 75 kW× 2 pieces Sliding frame
Feeding equipment	Sinter mix hopper Drum feeder Segregation device	30m^3, Load cell×3, 1200 φ, 2 ~ 8 rpm Sloping plate, Angle ≒ 55 °
Ignition furnace	Type of furnace Size Number of burners	Side burner type $2,260^{H} \times 22,270^{L}$ 18 burners ×both sides
Discharge equipment	Hot crusher Breaker bar slit Water cooling	2,390φ, 6 blades 150 mm (Blade depth :80 mm) Crusher axis and bar
Cooler	Type, Capacity Cooling air Size	Circular bin type, 1,800 t/h 350×$10^3$$m^3$/h ×250mmAq × 6 Blowers 31,100 φ×$1,250^{W}$ ×$7,700^{H}$
Screen	1st screen 2nd screen	650 t/h×4 , Open size:6×26/6×30 500 t/h×3 , Open size:28 φ
Main blower	Capacity Roter type, Motor	1.1×$10^6$$m^3$/h ×1,100 mmAq×3 Axial type 5000 kW×3
E. P.	Gas volume Voltage / electrode distance	3.0×$10^6$$m^3$/h , 4 ×3 fields 250 kV / 250 mm
Silo	Ore and coke breeze	150 m^3 × 10 bins
Drum mixer	1st mixer 2nd mixer	5φ× 15^{L} , 5.1 rpm Retention time : 3 min 5φ× 15^{L} , 4.95 rpm Retention time : 4 min
Heat recovery		None (For No.6 sintering plant, convenient heat recovery system for cooler waste gas is installed.)

Table II.3-6. Transition in Annual Production of Sinter

Year	No.1 ~ No.4		No.5, 6		No.7		Total
	Production	Downtime	Production	Downtime	Production	Downtime	
1980	4,548,962	M1 850	2,823,042		——		7,372,004
1981	4,077,683	M2 1,096	3,068,050		——		7,145,733
1982	4,402,607		2,922,204		——		7,324,811
1983	3,984,945	M3 472	2,493,780		532,546		7,011,271
1984	4,822,587	M3 248	1,381,328		634,350		6,838,265
1985	4,232,976		1,771,533	M5,6 2,029	2,636,409		8,640,918
1986	4,341,582	M4 376	2,529,504	M5 216	2,228,073		9,099,159
1987	4,081,093	M4 800 M1 1,245	2,186,660		1,315,835	1,016	7,583,588
1988	4,069,290	M2 1,405	2,428,113		1,831,517	2,184	8,328,920
1989	4,183,091		2,155,035		2,714,713		9,052,839
1990	3,130,880		1,980,055		823,217*	5,708	5,934,152
1991	1,784,727	M3 504	365,489	11,760	2,241,110	4,248	4,391,326
1992	1,910,688	7,341	950,408	4,416	1,470,926		4,332,022
1993	1,587,844	15,892	——	16,032	2,106,672		3,694,516

Downtime : Summation of big scheduled line stop time.

* : Due to modification of cooler receiving roller

Table II.3-7. MAIN OPERATION DATA
(COMPARISON OF SIDEX WITH JAPAN BY ANNUAL DATA IN 1992)

ITEM	UNIT	SIDEX			JAPAN
		No.1-3	No.5 & 6	No.7	
Grate area	m^2	156 2	192	500	320×28
Productivity	t/d/m^2	19.8	20.4	22.07	32.2
Workability	%	53.2	71.08	70.5	93
Bed height	mm	450	32-500	34-550	565
Raw material mix: mean size	mm	——	——	——	2.3
-125 μ	%	——	——	——	11
FeO	%	6.36	——	——	4.5
Burnt lime	kg/t	······	0	0	13
Yield S/S+R*	%	68.0	68.0	68.0	83.7
COKE	kg/t	72.6	72.36	72.36	37
Anthracite	kg/t	0	0	0	6
BF Dust	kg/t	12.8	0	0	8
Total	kg/t	85.4	72.36	72.36	51
Energy consumpt.	Mcal/t				335
COG	Nm^3/t	0	10.12	11.1	1.2
J:BFG/LDG, G:NG	Nm^3/t	6.43	0.76	1.64	0.2
PCI	kg/t	0	0	0	0.1
Energy consumpt.	Mcal/t				7.6
Elect. consumpt.	kWh/t	50.06	54.8	39.28	31.8
(Main Blower)	kWh/t				
Heat Recovery					
Steam	kg/t	0	0	0	40
Elect.	kWh/t	0	0	0	0.6
RDI	%	——	——	——	36.5
SI	%	——	——	——	89.5
J:TI, G:RUBIN	%	20.52	——	——	71.5
T.Fe	%	——	——	47.8	56.8
SiO_2	%	13.59	11.09	12.42	5.2
FeO	%	——	——	——	6.5
CaO/SiO_2	-	1.34	1.60	1.23	1.90

Table II.3-8. Unscheduled Shutdown* of No.7 Sintering Plant

	1 to 8 hours						More than 8 hours						Total	
	Due to operation		Due to equipment		Total		Due to operation		Due to equipment		Total			
	Frequency	Hours	Frequency	Hours	Frequency	Hours	Frequency	Hours	Frequency	Hours	Frequency	Hours	Frequency	Hours
1992. 11	5	13.45	14	33.97	19	47.42	1	10.40	0		1	10.40	20	57.82
1992. 12	0		13	31.5	13	31.5	7	75.3	0		7	75.3	20	106.8
1993. 1	3	14.95	10	22.6	13	37.55	3	28.75	0		3	28.75	16	66.3
1993. 2	3	15.45	10	26.7	13	42.15	0		0		0		13	42.15
1993. 3	2	10.45	14	41.05	16	51.5	1	8.15	1	30.15	2	38.3	18	89.80
1993. 4	7	30.95	9	27.25	16	58.2	2	17.55	1	9.25	3	26.8	19	85.00
1993. 5	2	7.60	12	34.24	14	41.84	5	50.4	1	16.35	6	66.75	20	108.59
1993. 6	0		0		0		9	123.75	0		9	123.75	9	123.75
1993. 7	8	36.25	6	22.95	14	59.20	13	174.75	0		13	174.75	27	233.95
1993. 8	13	52.40	2	12.9	15	65.30	12	126.11	0		12	126.11	27	191.41
1993. 9	9	32.45	5	8.4	14	40.85	8	107.95	2	20.8	10	128.75	24	169.60
1993. 10	3	19.45	5	10.25	8	29.70	2	24.65	0		2	24.65	10	54.35
Total	55	234.40	100	271.81	155	505.21	63	747.76	5	76.55	68	824.31	223	1329.52

* Due to operation : 10 times/month. 82 hours/month(decrease of operational availability by 11.2%)

Due to equipment : 9 times/month. 29 hours/month(decrease of operational availability by 4.0%)

Table II.3-9. Monthly Operation Results of No. 7 Sintering Plant in 1993

Item	Unit	SIDEX (1993)											Japan
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	1992
(1)Productivity	$t/d/m^2$	18.40	20.57	19.89	22.34	21.86	23.46	21.02	20.81	19.95	14.79	15.90	32.2
(2)Operational availability	%	75.1	76.7	69.1	75.9	61.8	40.7	50.2	54.9	53.6	83.3	53.2	93.0
(3)T.Fe (Average)	%	47.64	49.03	52.36	53.73	54.37	53.10	49.53	53.70	52.79	57.45	53.77	56.8
(4)CaO (Average)	%	14.84	14.36	11.51	10.68	9.74	12.78	17.18	11.79	13.23	8.45	11.88	9.4
CaO (σ)													0.2
(5)SiO_2 (Average)	%	12.77	11.95	9.24	7.89	7.15	7.55	7.95	7.42	7.72	5.13	6.91	5.2
SiO_2 (σ)	%												0.15
(6)Coke consumpt.	kg/t	72.16	72.34	72.52	72.18	72.67	72.07	72.18	72.23	72.22	72.30	72.22	51.0
(7)COG consumpt.	Nm^3/t	8.28	9.28	7.92	6.55	9.46	6.49	11.47	8.10	9.68	8.65	9.93	2.0
(8)Elect. consumpt.	kw/t	38.94	39.68	38.87	34.81	34.92	31.46	35.30	34.57	36.29	51.67	45.78	31.8