JAPAN INTERNATIONAL COOPERATION AGENCY (JICA) No. 36

MINISTRY OF INDUSTRY
VIET NAM STEEL CORPORATION
THE SOCIALIST REPUBLIC OF VIET NAM

THE MASTER PLAN STUDY ON THE DEVELOPMENT OF THE STEEL INDUSTRY IN THE SOCIALIST REPUBLIC OF VIET NAM

FINAL REPORT

March 1998

NIPPON STEEL CORPORATION

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PREFACE

In response to a request from the Government of the Socialist Republic of Viet Nam, the Government of Japan decided to conduct the Master Plan Study on the Development of the Steel Industry in Viet Nam, and entrusted the study to Japan International Cooperation Agency (JICA).

JICA sent a study team, led by Mr. Kenji Kobayashi of Nippon Steel Corporation and constituted by members of Nippon Steel Corporation and four major steel companies with a specialized consulting firm, to the Socialist Republic of Viet Nam six times from October 1996 to January 1998.

The team held discussions with the officials concerned of the Government of the Socialist Republic of Viet Nam, and conducted related field surveys. After returning to Japan, the team conducted further studies and compiled the final results in this report.

I hope this report will contribute to the steel industry development in the Socialist Republic of Viet Nam 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 the Socialist Republic of Viet Nam for their close cooperation throughout the study.

March 1998

Kimio Fujita
President
Japan International Cooperation Agency

March 1998

Mr. Kimio Fujita

President
Japan International Cooperation Agency - JICA
Tokyo, JAPAN

Dear Mr. Fujita,

<u>Letter of Transmittal</u>

We are pleased to submit herewith the Final Report of "the Master Plan Study on the Development of Steel Industry in the Socialist Republic of Viet Nam".

The Report contains the advices and suggestions of the authorities concerned of the Government of Japan and JICA as well as the formulation of the above study. Also included are comments and wishes made by the governmental officials of the Socialist Republic of Viet Nam including officials of ministries concerned and Vietnam Steel Corporation at the technical discussions during site investigation and draft report presentation held in Hanoi, Viet Nam.

This report presents the Master Plan of steel industry in Viet Nam up to the year 2010, indicating firstly the foreseeable steel demand in the future, direction of improvement and expansion of the existing steel plants (rehabilitation), the necessity of constructing an integrated steelworks, the process technology to be adapted by such integrated steelworks, etc., and secondly the results of pre-feasibility study on the construction of an integrated steelworks including financial analysis.

Steel industry is generally conceived as a core industry of a country, however, careful approach and precise examination by Viet Nam side are recommended in view of its heavy investment.

We wish to take this opportunity to express our sincere gratitude to JICA, the Ministry of Foreign Affairs, Ministry of International Trade and Industry. We also wish to express our deep gratitude to the Ministry of Planning and Investment, the Ministry of Industry, Vietnam Steel Corporation and other authorities concerned of the Socialist Republic of Viet Nam for the close cooperation and assistance extended to us during our investigation and study.

Very truly yours,

Kobayashi, K.

Kenji Kobayashi
Leader
Master Plan Study on the
Development of Steel Industry
in the Socialist Republic of
Viet Nam

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List of Abbreviations

AFTA:	ASEAN Free Trade Area
ASC:	Apparent Steel Consumption
ASEAN:	Association of South-East Asian Nations
b.scf:	billion standard cubic feet
B/C:	Buyer's Credit
BAF:	Box Annealing Furnace
BF:	Blast Furnace
BF&BOF	Blast Furnace and Basic Oxygen Furnace
BFG:	Blast Furnace Gas
BOF:	Basic Oxygen Furnace
BOFG:	Basic Oxygen Furnace Gas
BOT:	Build, Operate, Transfer
BPD:	Barrel Per Day
BT:	Billet
BTC:	Billet Center
CAL:	Continuous Annealing Line
CAPL:	Continuous Annealing & Processing Line
CAS:	Composition Adjustment by Sealed argon bubbling (Simplified ladle refining)
CAS-OB:	CAS Oxygen Blowing (process)
CBM:	Coil Box Mill
CC:	Continuous Casting
CCC:	Continuous Continuous Casting (Sequence casting)
CCM:	Continuous Casting Machine
CGC:	Commercial Grade Continuous Casting steel
CGL:	Continuous Galvanizing Line
CO:	Coke Oven
CO:	Carbon monoxide
COD:	Chemical Oxygen Demand
COG:	Coke Oven Gas
CPL:	Coil Preparation Line
CQ:	Commercial Quality
CRI:	Coke Reaction Index
CRM:	Cold Rolling Mill
CSM:	Cold Strip Mill
CSP:	Compact Strip Production
CSR:	Coke Strength after Reaction
CVM:	Conventional three quarter Mill
CVP:	Conventional CC-Hot Process
DC:	Down-Coiler

DDQ:	Deep Drawing Quality
DH:	Dortmund Horder (vacuum degassing process)
DHCR:	Direct Hot Charge Rolling
DI:	Drum Index
DL:	Dwight Lloyd(type sintering machine)
DQ:	Drawing Quality
DR:	Direct Reduction
DRI:	Direct Reduced Iron
DWT:	Dead Weight Ton
E/N:	Exchange of Note
EAF:	Electric Arc Furnace
ECL:	Electrolytic Cleaning Line
EGL:	Electrolytic Galvanizing Line
ERW:	Electric Resistance Welding
ETL:	Electrolytic Tinning Line
EXIM:	Export-Import Bank(s)
F/S:	Feasibility Study
FDI:	Foreign Direct Investment
FM:	Finishing Mill
FOB:	Free On Board
GDP:	Gross Domestic Product
GI:	Galvanized Iron
GNP:	Gross National Product
H.W.L:	High Water Level
HBI:	Hot Briquetted Iron
HCMC:	Ho Chi Minh City
HD:	Hot Dip
Hema:	Hematite
HMR:	Hot Metal Ratio
HMS:	Heavy Melting Scrap
HP:	High Power
HPCL:	Heavy Plate Cutting Line
HSHL:	Hot Shear Line
HSM:	Hot Strip Mill
HSPM:	Hot Skinpass Mill
HSRL:	Hot Slitting and Recoiling Line
IBRD:	International Bank for Reconstruction and Development
IC:	Iron Carbide
IDA:	International Development Association
IFC:	International Finance Corporation
IG:	Ingot Casting
IISI:	International Iron and Steel Institute

ISP:	In-line Strip Production
JDB:	Japan Development Bank
JICA:	Japan International Cooperation Agency
JIS:	Japanese Industrial Standard
JV:	Joint Venture
L/3:	Level 3 computer system
L/G:	Letter of Guarantee
P/O:	Pickled and Oiled sheet and strip
LD:	Linz-Donawitz process
LDG:	LD Gas
LF:	Ladle Furnace
Limo:	Limonite
LPG:	Liquid Propane Gas
Mag:	Magnetaite
MIGA:	Multilateral Investment Guarantee Agency
M-DEMAG:	Mannesmann DEMAG
MITI:	Ministry of International Trade and Industry
MMBTU:	Million British Thermal Unit
MOC:	Ministry Of Construction
MOI:	Ministry Of Industry
MOSTE:	Ministry Of Science, Technology and Environment
MPI:	Ministry of Planning and Investment
MPN:	Most Probable Number
MSP:	Medium-thickness Slab Process
NISW:	New Integrated Steelworks
NOF:	Non Oxidized Furnace
ODA:	Official Development Assistance
OECD:	Organization for Economic Co-operation and Development
OECF:	Overseas Economic Cooperation Fund
PABX:	Private Automatic Branch Exchange
PAX	Private Automatic Exchange
PEB:	Pre-Engineered Building
PL:	Pickling Line
PR	Public Relations
R&D	Research and Development
RCL:	Re-Coiling Line
RCM:	Reverse Cold-rolling Mill
RF:	Reheating Furnace
RH:	Rheinstahl Huttenwerke und Heraus (vacuum degassing process)
RHF:	Rotary Hearth Furnace
RM:	Roughing Mill

S/C	Supplier's Credit
S/S:	Sub-Station
SBQ:	Special Bar Quality
SEAISI:	South East Asia Iron & Steel Institute
SM:	Sintering Machine
SPM:	Skinpass Mill
SPW:	Spiral Pipe Welding
SR:	Smelting Reduction
SSC:	Southern Steel Corporation
T-T:	Tap to Tap Time
TCM:	Tandem Cold-rolling Mill
TEU:	Ton Equivalent Unit
TFS:	Tin Free Steel
TISCO:	Thai Nguyen Iron and Steel Corporation
TMBP:	Tin Mill Black Plate
TPM:	Temper Mill
TSP:	Thin Slab Process
UC:	Unit Consumption
UHP:	Ultra High Power (operation)
UOE:	U-ing O-ing and Expanding (pipe process)
VAD:	Vacuum Arc Degassing
VAI:	VOEST ALPINE Industieanlagenbau GmbH
VD:	Vacuum Degassing process
VM:	Volatile Matter
VND:	Vietnamese Dong
VOD:	Vacuum Oxygen Decarburization (process)
VSC:	Viet Nam Steel Corporation
WB:	World Bank

Chapter I Background to "the Master Plan Study on the Development of the Steel Industry in the Socialist Republic of Viet Nam"

Part 1 Background to "the Master Plan Study on the Development of the Steel Industry in the Socialist Republic of Viet Nam"

Section 1 Background to "the Master Plan Study on the Development of the Steel Industry in the Socialist Republic of Viet Nam"

Contents

1. Background to the study

After Viet Nam won its independence from France (September 1945), it went through a long period of war. In July 1976, the unification of North and South was realized, and the Socialist Republic of Viet Nam has since then been engaged in postwar reconstruction under a socialistic system. In December 1986, the country decided to adopt Doi Moi (reform) policy, and this policy aims at:

(1) relaxation of the centrally planned production, introduction of the independent profit system, and introduction of the production contracting system

(2) placing weight of production on food, essential goods and export goods

(3) opening economy to outside, and legislation for accepting foreign investments.

Afterwards, agricultural produce remarkably increased under the policies of reducing agricultural tax rates etc.

On the other hand, although inflation advanced in the latter half of the 1980's, it was successfully restrained by inflation control policies such as reduction in government subsidies, tight budget, interest rate raising, and curbing of the rise of wages. Owing, however, to the influence of the collapse of the USSR, the COMECON trade system was disrupted, and trade settlement by hard currency became necessary. Then, because of the cessation of economic assistance from Russia and the shortage of imported fundamental materials due to chronic shortage of foreign currencies, the resurgence of inflation has been feared.

A new economic plan was adopted at the Seventh National Congress in 1991, which aims to achieve, while promoting market economy, an annual growth rate of 4-5% in agriculture and 10-12% in industry over a period of 10 years accomplishing GDP in the year 2000 double that in 1990.

At the Eighth National Congress in June last year, an average annual growth rate of 8.2% in GDP from 1991 to 1995 was confirmed, and it was also announced that the country would strive to grow to be an industrial nation by the year 2020.

The production of iron and steel used to be controlled by Vietnam Steel Corporation (VSC), a substructure of the Ministry of Industry, which controls materials industries.

The steel industry today has an imbalance between the upstream process which produces crude steel and the downstream process which manufactures rolled products. The combined North and South annual production by the upstream process is said to be about 300,000 tons while the annual production by the downstream varies from 1,000,000 to 1,500,000 tons. This gap in production capacity seems to have been filled with imported semi-products. It is strongly felt, however, that the construction of an integrated steelworks to resolve this imbalance problem and the introduction of a structure for producing steel products for shipbuilding and automotive applications expected during 2000-2010 are urgent.

The actual production of steel products in 1995 was about 500,000 tons while the domestic demand in the same year was about 1,100,000 tons. The gap amounting to about 600,000 tons was filled with imported steel products.

The domestic demand projection for 2000 is said to be about 3,500,000 tons. The Government of Viet Nam has requested Japan to carry out master-plan planning for the promotion of the steel industry and a pre-feasibility study for the construction of an expected new integrated steelworks in Viet Nam.

To respond to this request, the Japan International Cooperation Agency dispatched a pre-survey mission from June 6 to 15, 1996 to Viet Nam to discuss the details, scope, etc., of the feasibility study based on the background and history to the request. As agreement was reached with the Government of Viet Nam, the agreement document on the scope of work (S/W) of the feasibility study was signed on June 12.

2. Purposes of the study

The purposes of the study are:

(1) to work out a master plan for the promotion of the steel industry, first by obtaining the information on the future outlook (2010) and supply-demand projections based on socioeconomic policies, development plans, and the present state of the steel industry, secondly by examining viable domestic projects and sites from the conditions of domestic resources, site conditions, etc., thirdly by planning an optimum production structure required for the Vietnamese steel industry in 2010 including the revamping of existing works, and lastly by suggesting crucial policies;

(2) to carry out a pre-feasibility study on the priority project selected by the Viet Nam side if a decision is made that the construction of a new steelworks is necessary as a result of the master plan study; and

(3) to transfer the technology of making various polices for the promotion of the steel industry, feasibility study procedures, etc., to the Vietnamese counterparts.

3. Study schedule

This study, following the preparatory work in September 1996, was started by dispatching the first site-study mission and conducted as shown in Figure 1-1.

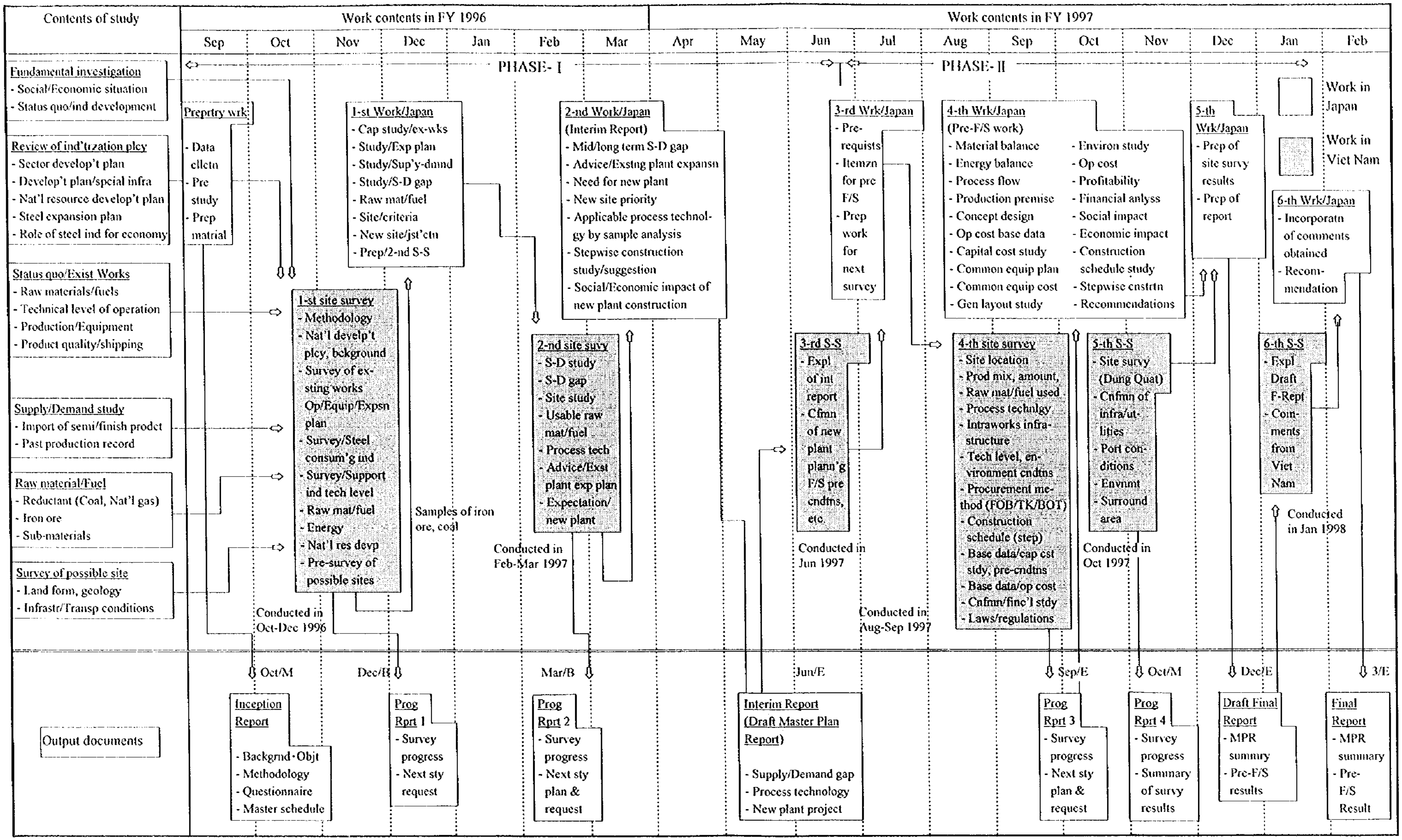


Figure 1-1 Overall Schedule of Master Plan & Pre-Feasibility Study

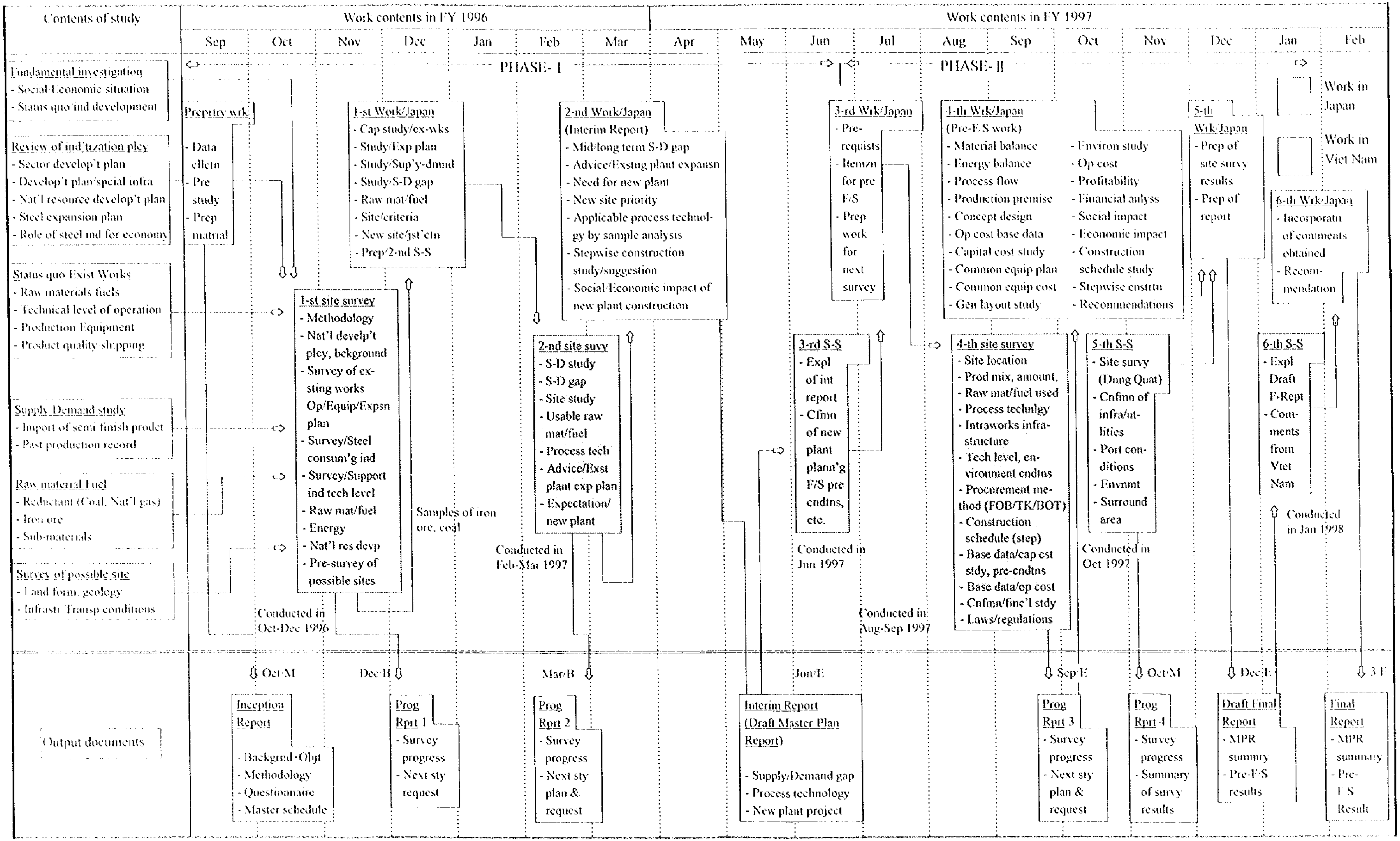


Figure 1-1 Overall Schedule of Master Plan & Pre-Feasibility Study

4. Study organization

The members of the Japanese group organized for this study are shown in Figure 1-2.

The members of the Vietnamese group who cooperated with the Japanese group at site are shown in Figure 1-3.

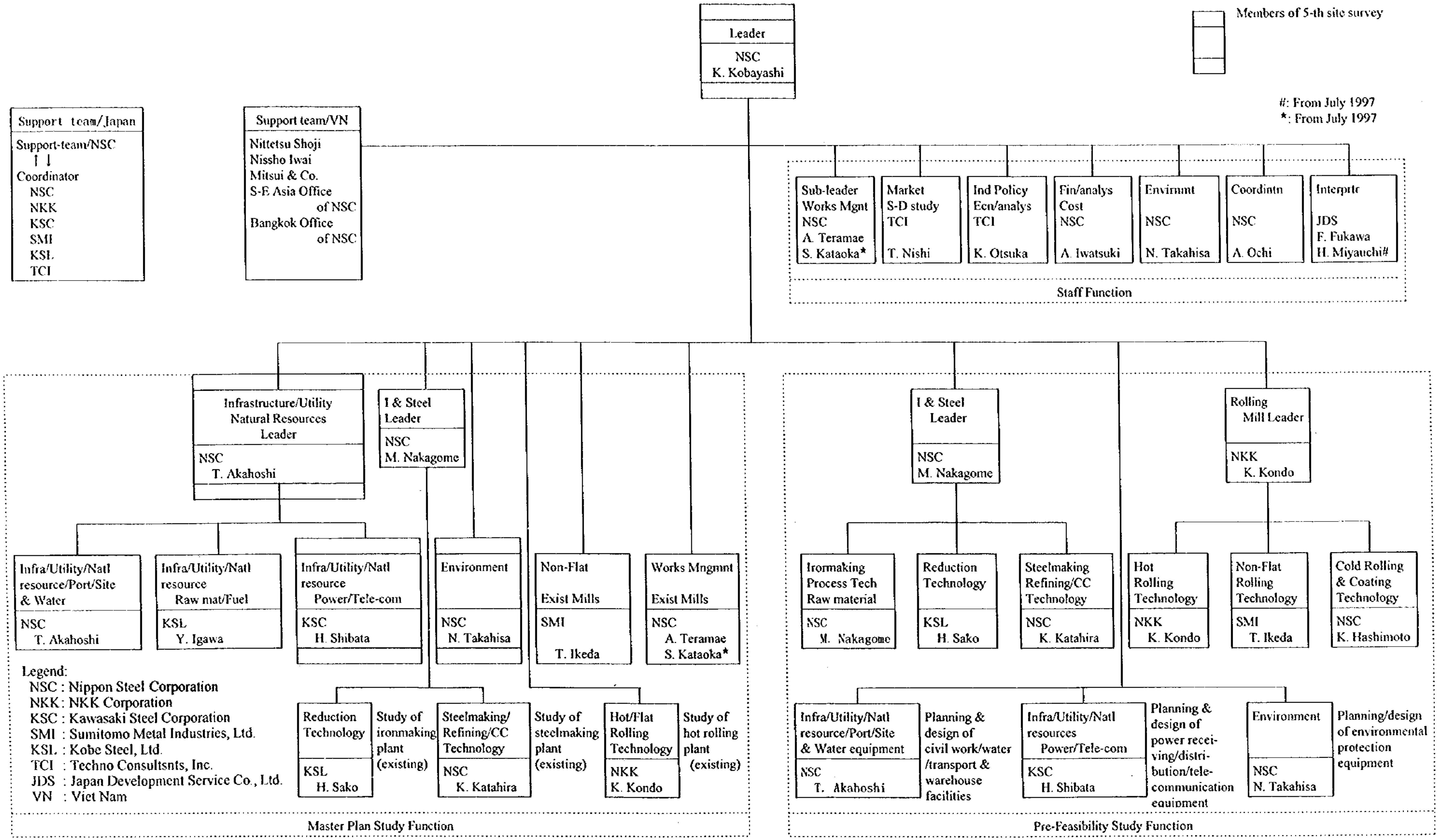


Figure 1-2 Study Members & Its Organization

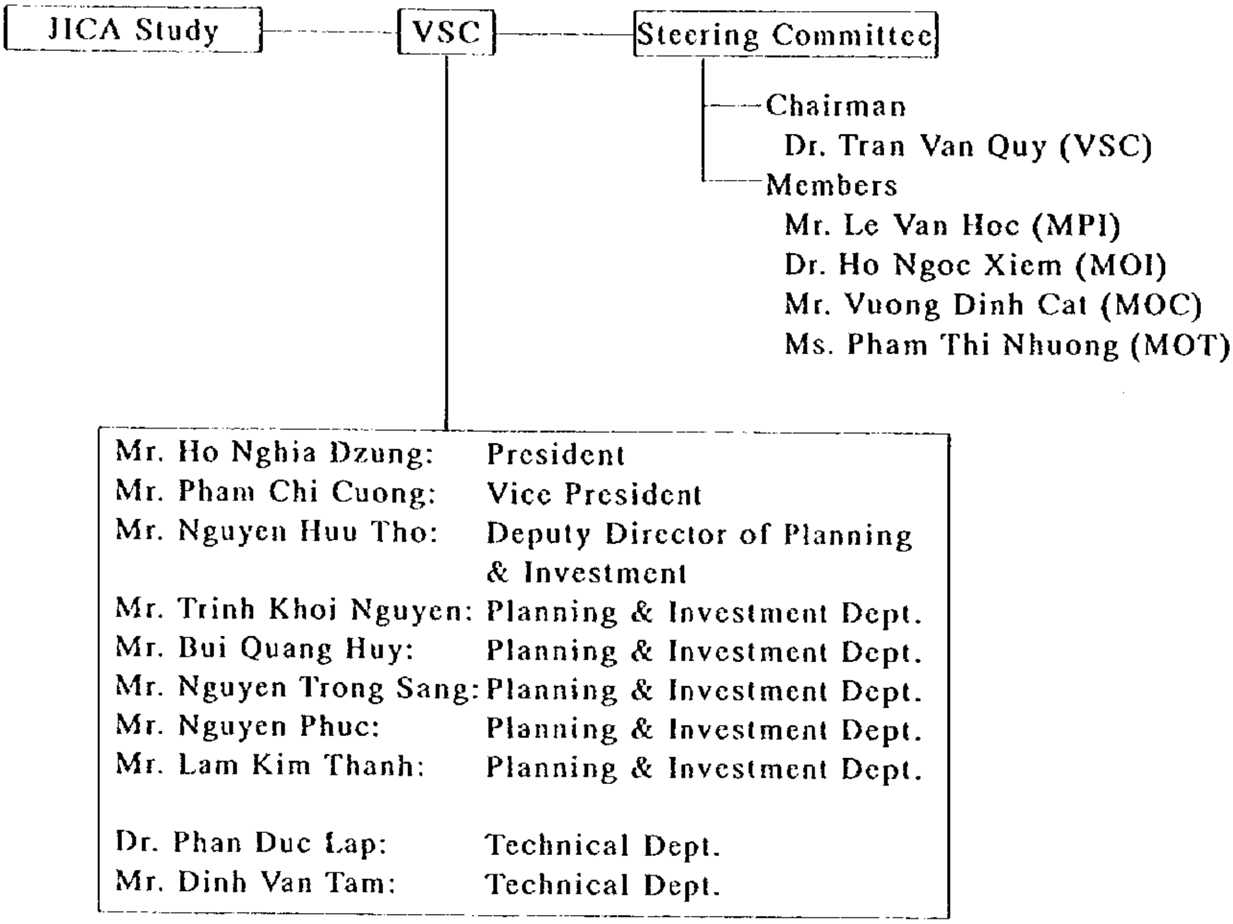


Figure 1-3 Vietnamese counterparts

Chapter II Present Situation of the Steel Industry in Viet Nam

Part 1 Organization and Administration of Viet Nam Steel Corporation

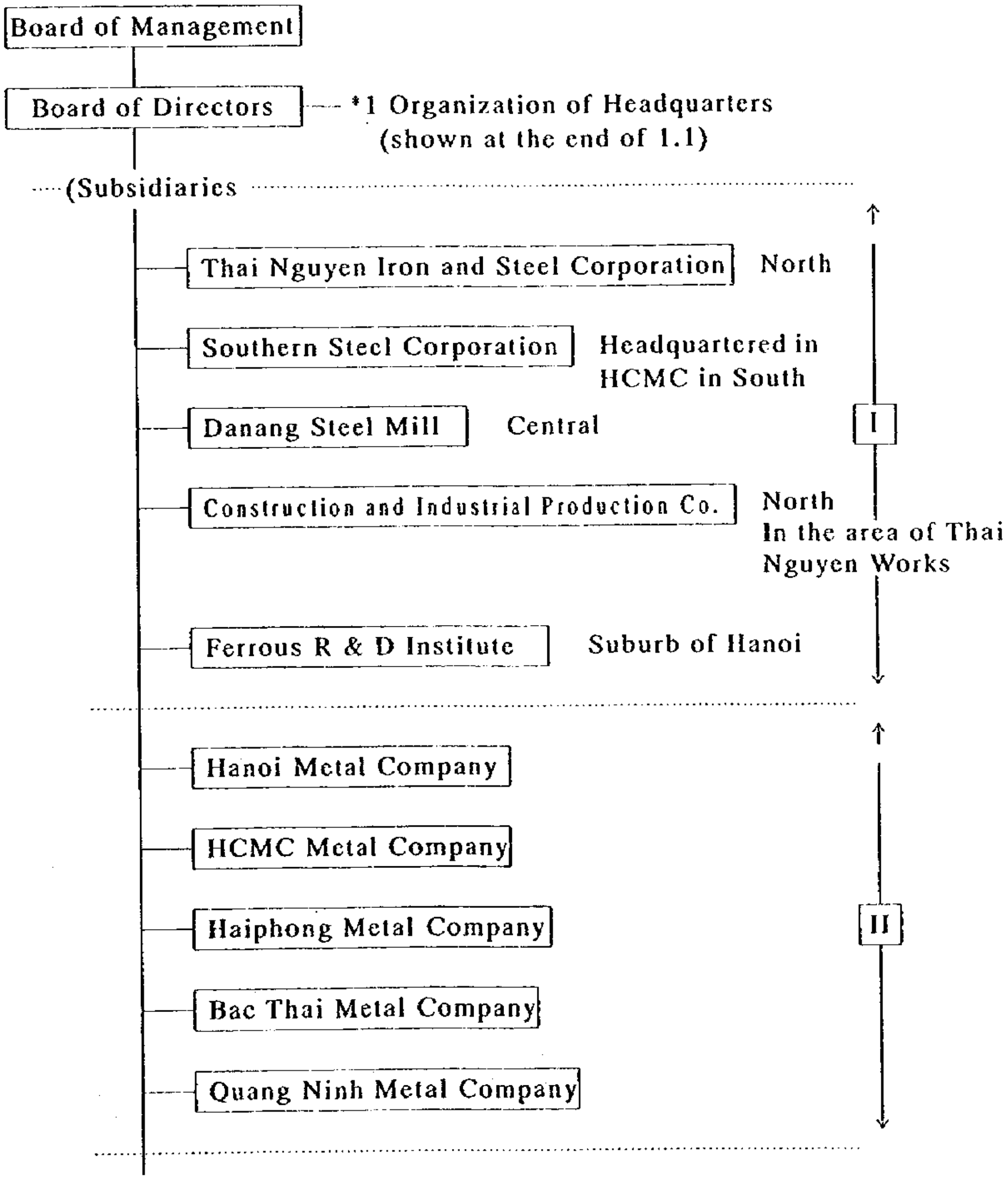
Section 1 Organization and Administration of Viet Nam Steel Corporation

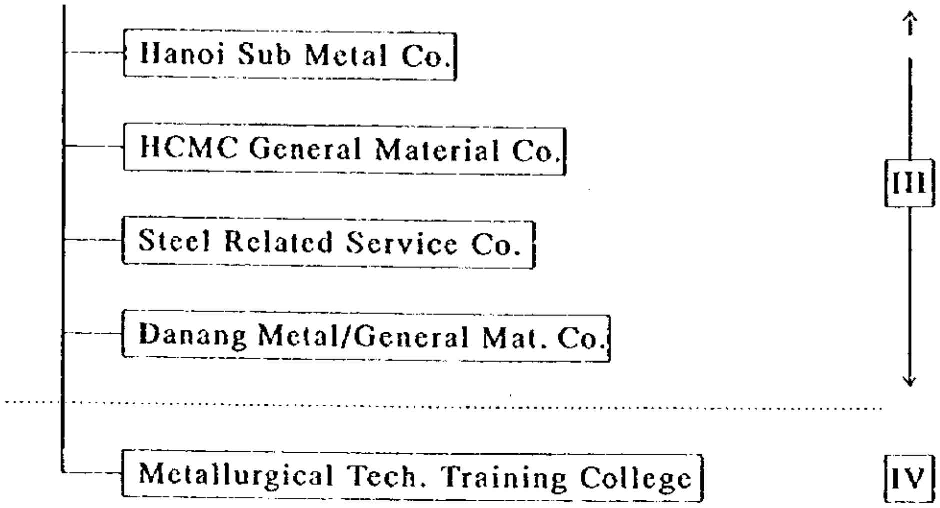
Contents

1. Organization and management of Viet Nam Steel Corporation

1.1 Organization of VSC

The organizational structure of VSC is shown below.





VSC, is a large state owned corporation established pursuant to the Decision No. 255/TTg dated April 29, 1995 of the Prime Minister, Decree No. 03/CP dated January 25, 1996 of the Government to approve the statutes and operation organization of the Corporation and business registration No. 109612 dated February 5, 1996 issued by the Ministry of Planning and Investment, empowered to plan policies by itself and propose them to the higher level of administration, and, at the same time, has been required to operate on the independent profit system. In matters of personnel and budget, however, VSC implements steel industry policies in close communication with the Ministry of Industry.

As has been shown above, VSC is largely composed of four subsidiary departments. The main business of Department I is mainly the production of steel products and the construction of equipment related to it.

As the details of each mill are explained in the next section, a brief description of each mill is given here.

The Thai Nguyen Works, the only one integrated works in Viet Nam, has three blast furnaces, actually one in operation whose inner volume is $100m^3$ and turns all hot metal into cold pig-iron to be put in electric arc furnaces together with scrap, and after refining, manufactures reinforcing bars and shapes.

The Southern Steel Corporation (abbreviated as SSC) is a group of EF and rolling mill plants. These plants used to be independent private mills, but have been consolidated for nationalization. Their equipment is aged, and each mill production capacity is low.

The Danang Steel Mill is a mini-mill with electric arc furnace of 1.5-ton capacity and a parallel-type bar mill.

The Ferrous R&D Institute, located in the suburbs of Hanoi, lacks in research equipment, and therefore needs reinforcements.
Although executives are sometimes sent to SSC from the North, the exchange of personnel between the North and South is not frequently realized.

Department II is mainly in charge of the sale of steel products, and is generically called Vina-Metal. This department is also responsible for importing steel products when the domestic demand exceeds production.

Department III is in charge of arranging the procurement of iron and steel raw materials and importing special steels and nonferrous metals except plain carbon steel. This department is also responsible for business diversification.

Department IV is an organization for training workers, and about 1,000 people are registered. The training period is 3 years.

*1 Organization of VSC Headquarters (manned with about 100 people according to the explanation)

Board of Management — Chairman + 4 members
BOM Assistant & Advisors 5

Board of Directors — President + 2 vice presidents

Administration — 40

- Personnel Dept. 12
- Accounting & Finance 12
- Planning & Investment 15
- Trading & Imp. - Exp. 22
- Technical Dept. 5 (Safety, Quality, Environment)
- Thach Khe Iron Ore Project 5

(124)

1.2 Joint ventures of VSC

The joint ventures between VSC and foreign capital are shown below.

(1) VSC-POSCO Steel (Production of steel products for building construction)

(2) Vina-Pipe Corporation (Production of weleded-pipes)

(3) Vina-Kyoei Steel Co. (Production of steel products for building construction)

(4) International Business Center

In addition to the above, there are joint ventures between subsidiaries of VSC and foreign capital as shown below.

(1) Southern Steel Sheet Co., Ltd. (Galvanizing and color coating)

(2) Colour Sheet Processing Center NIPPOVINA (Color coated sheet processing for building construction)

(3) NatSteel Vina Company (Production of steel products for building construction)

(4) POSVINA Co., Ltd. (Production of galvanized steel sheets for building construction)

(5) VINGAL INDUSTRIES Co., Ltd. (Galvanizing pipe and processed products)

(6) VINAUSTEEL Ltd. (Production of steel products for building construction)

(7) Tydo Steel Co., Ltd. (Production of steel products for building construction)

(8) Vinanic Steel Processing Company (Coil center)

(9) Long Binh Steel Co., Ltd. (Production of steel structures, cold forming and welding products, etc.)

(10) Sigon Steel Co., Ltd. (Coil center)

1.3 Present state of VSC's management activities

VSC was approved as a nationalized company on January 25, 1996 pursuant to a government ordinance issued on April 29, 1995, and registered as an organization to promote business activities in production and sale of steel and nonferrous metals throughout Viet Nam.

VSC is virtually a holding company of 16 subsidiaries and 13 joint ventures (12 on the above organization chart) with foreign capital.
The main business activities of VSC are as follows.

(1) Exploitation of iron ore and raw materials mines related to the steel industry

(2) Production of steel and other metals, and manufacture of steel products

(3) Trade and services related to steel, metals, iron ore and raw materials, materials (including sub-materials) for steel production, machinery and spare parts for the steel industry

(4) Designing, manufacturing, building and assembling for steel production facilities

(5) Training of personnel, and technical and scientific research for steel production

(6) Hotel business, and other services in accordance with the laws and regulations of the Socialist Republic of Viet Nam

Steel production, the main business of VSC, has been at low levels, as detailed in the following section, at about 300,000 tons in 1996 because crude steel production by the electric arc furnace process suffered from insufficient equipment capacity, scrap shortage and unstable supply of electricity.

On the other hand, the domestic demand for steel products focusing on reinforcing bars was 1,300,000 tons including that for market stocks in 1996, and the domestic production of rolled steel products, except imports and stocks, in 1996 amounted to about 1,000,000 tons. A difference of 700,000 tons from the crude steel production, therefore, was produced from imported billets.

Joint ventures with foreign capital started operation one after another in 1995 and 1996. Among these joint ventures, VSC-POSCO, NatSteel, Vina-Kyoei, and VINAUSTEEL are each re-rolling makers with modern rolling mill equipment. None of them, however, has melting equipment, namely, electric arc furnaces. The total rolling capacity of VSC and joint venture companies is estimated at about 1,500,000 tons/year. If each of these joint ventures should individually import billets and roll them, their production would be excessively large, and the market price of reinforcing bars would drop.

In fact, mills under the control of VSC and SSC as well as joint ventures carried out extensive production cutbacks in 1996. If the equipment and facilities of joint ventures should be fully operated, VSC with obsolete and aged equipment would face the problem of a poor level of competitiveness in terms of cost and quality. Therefore, the strong leadership of VSC in production adjustment and the modernization of mills under its control by restructuring and consolidation are necessary.

Part 2 Present Situation of Existing Steel Plants and Direction of Their Rehabilitation

Section 1 Raw Material

Contents

1. Preface

It has been reported that many deposits of raw materials for steel industry exist in Viet Nam and this section evaluates the present situation of mines supplying raw materials to existing steel industries and the potentiality of production increase from deposits from the view point of stable supply for long term.

2. Iron ore

Table 1-1 lists up the significant iron ore deposits which are known to exist in Viet Nam.

Table 1-1 Iron ore deposits in Viet Nam

Deposit Name	Type of Ore	T.Fe	Geological Reserve *1	Mineable Reserve *1
Thach Khe	Magnetite and Hematite	About 61%	540	320
Trai Cau	Magnetite and Limonite	Mag:61-62% less than 55%	11.4	9.0
Quy Xa	Limonite	About 53%	118	98
Cao Bang	Magnetite	About 60%	37	not available
Ha Giang	Magnetite and Hematite	Less than 40%	128	not available
Tien Bo	Limonite	About 43%	21	not available

*1 Unit: million t

Trai Cau is the only iron ore mine in Viet Nam producing iron ore at the present time and it supplies lump ore to TISCO. The other deposits are not exploited. The quality of the lump ore sampled at Luusa steel works in TISCO is shown in Table 1-2 and compared to the chemistry of Australian lump ore which is a fairly representative lump ore for reference. From the figures it can be seen that Trai Cau has a high alumina and crystal water (or combined water) (CW) content.

Table 1-2 Ore quality of Trai Cau mine

	Total Fe	SiO_2	Al_2O_3	P	Zn	CW	D.T.
The Ore	63.1	1.1	5.2	0.007	0.015	3.8	92.6
Australian ore	65.4	3.4	1.1	0.048	0.002	1.4	90.1

D.T.: +8.0mm% after Decrepitation Test

Table 1-3 shows an analysis of the SiO_2 and Al_2O_3 with size fraction and distribution before and after washing. In finer sizes, the iron content is relatively low and the size fraction after washing becomes larger. This means that this ore is contaminated with adhesive clay material or gang minerals. It would normally understood that this ore is not suitable for big scale blast furnace.

Table 1-3 Chemistry and size of the ore

Size (mm)	T.Fe	SiO_2	Al_2O_3	Size fraction after washing (%)	Size fraction before washing (%)
-0.045	56.1	4.1	8.7	0	3.2
0.25-0.5	61.4	2.4	4.1	0.4	0.5
2.8-4.8	65.3	0.9	2.2	6.2	5.8
4.8-8.0	61.8	1.4	5.5	40.4	40.1
8.0-16.0	67.9	0.2	1.1	43.3	40.0
0-16.0	63.1	1.1	5.2		

The production level in long term plan is around 200,000 tons per year. From the present mineable reserves at this mine it can be expected for this production to increase.

Thach Khe iron ore deposit is the only one from which it is possible to supply ore to a large scale steel plant as it has a large reserve of ore with a high Fe content as shown in the Table 1-1. The recent study to evaluate Thach Khe iron ore has been canceled partly because of its high zinc content which complicates present iron making procedures and partly because of the smaller than expected reserve due to complicated structure of the deposit. On the other hand, exploration for other iron ore deposit is not being done. Therefore it can be concluded that under present exploration results and with present iron making technology there is no viable resource in Viet Nam for a large scale steel plant.

3. Oil and natural gas

There are eight basins in the Viet Nam off shore where oil and gas could be found. In the north of Viet Nam exploration for oil and natural gas started in late 1950s. Since 1973 in the south of Viet Nam exploration concessions have been awarded to foreign oil and gas companies.

The following are the general information about 6 out of 8 basins with potentiality of oil and gas covered by first stage exploration at present.

(1) Hanoi Trough

Gas and condensate were detected in anticline structures associated with the faults. This area is believed to be potentially rich in gas.

(2) Red River (Song Hong) basin in the north

Some oil condensate and gas were discovered but not in commercial quantities.

(3) Phu Khanh basin in the center

A deep water basin in which seismic surveys and two wild cat showed no discoveries.

(4) Cuu Long (Mekong) basin in the southeast

There is production in two oil fields at Bach Ho and Rong and new discoveries are being made. This is one of the most prospective basins.

(5) South (Nam) Con Son basins.

Oil and gas discoveries were made and it seems to be a very promising area. The Dai Hung oil field is already under production and recently there have been many oil and gas discoveries.

(6) Malay Basin in south west

Area with high potential for the presence of hydrocarbon

Oil and gas are produced only in the southeast part of Viet Nam at present and also explorations are being done actively in this area. Some reports state that oil and gas have a tendency to exist in fractured granite basement and Miocene sands and this makes discoveries of oil and gas and evaluation of proven reserve difficult.

In 1995, the production rate of oil and gas was 190,000 barrels per day and 2.7 million cubic meter per day respectively from Bach Ho oil field mainly. Production from this field is anticipated to decrease after 2000.

Oil production is planned to reach to the rate of 530,000 barrels per day in 2010 from oil fields other than Bach Ho oil field.

With respect to the future production of natural gas, follows are the only information possible to know.

Two dry gas wells with proven reserve are to be exploited certainly in near future as shown in Table 1-4.

Table 1-4 Gas reserves in future

Fields or well	Basin	Reserve (b.scf*1)
Lan Do & Lan Tay	Nam Con Son	2,000
Well in block 11-2	Nam Con Son	1,000

*1 billion standard cubic feet

- Lan Do and Lan Tay fields
  Production will start in the near future with reserve of 2 trillion cubic feet.
- Gas wells in block 11-2
  Production will start in the near future with reserve of 1 trillion cubic feet.
- These two wells will be exploited definitively in near future and Nam Con Son Project will combine these two with pipe line and transport gas to on-shore from these 2 wells.

Gas reserves in above-mentioned wells are not so big compared with anticipated future consumption. The period of viable gas production from these wells will not exceed 30 years (reserve of 3 trillion scf =10 million cubic meter/d production for 23 years).

More than 10 million cubic meter per day is planned to be used for electric power generation by the year 2010 and in this sense, under the present plan of gas usage and with present proven reserves, gas can not be relied on as the main fuel source for large scale iron making process.

Also natural gas can be produced from oil well as associated gas. As the ratio of associated gas is estimated to be around 100 m^3-gas/ t-oil at the present time and the total production of associated gas is so small that the associated gas is not taken into account.

4. Coal

Most of the coal reserves in Viet Nam are anthracite and total mineable reserve are calculated to be 3.5 billion tons at annual production of 9 million tons in 1996. The scheduled increase of production 2 to 3 million tons per year requires an investment of US$3 million per year.

Table 1-5 Quality of anthracite from Hongai

	VM	Ash	TS	C	H	N	O	Maximum fluidity	Free swelling index
Deo Nai	6.22	3.3	0.44	90.2	4.1	1.0	1.1	0	0

Sample of anthracite coal analyzed in Table 1-5 from Deo Nai mine in Hongai is lumpy bright coal which has lower ash content compared with average quality coal from the mine and the maximum fluidity of 0 compares with the ordinary coking coal maximum fluidity of around 1.0. Maximum fluidity is one of the most important properties for coking coal. So, it can not be used as coking coal.

Table 1-6 shows proven reserves of bituminous coal in Viet Nam, part of which would may be ranked as coking coal. These reserves are very small and only a small quantity of coking coal at the present is mined for TISCO from Lang Cam mine, which has a production of 90,000 tons per year from 3,600,000 tons of mineable reserve. At the moment there is no substantial source of coking coal for large scale iron making process in Viet Nam.

Table 1-6 Bituminous coal reserves
(as of 1 January, 1986)

Unit: million t

Field of area	Possible reserves	Proven reserves
North area	9	7
Da River field	4	4
Nghe Tinh area	2	1

5. Other raw materials for iron making

Table 1-7 shows the natural resources near TISCO which shows abundant resources of raw materials like limestone and quartz near the plant.
This conditions about the materials are the same all over the country.

Table 1-7 Natural resources near TISCO

Mine Name	Mineral	Mineable Reserve (1,000 t)	Actual Mining Capacity (1,000 t/y)	Quality	Transportation
Nui Voi	Limestone	15,200	150	CaO:51-54.0%	Truck
Khanh Hoa	Dolomite	1,410	20	MgO:12-21.5% CaO:30-34.6%	Truck
Vin Phu	Quartz	1,200	5	SiO_2>94%	Truck
Tuyen Quang	Chamotte	850	10	SiO_2:68.29%, Al_2O_3:20.14%,	Truck
Truc Thon	Clay	7,200	15		Truck
Thanh Hoa	Dolomite	2,680	2	MgO:18-19.8% CaO:32-33%	Truck

Section 2 Ironmaking Operation

Contents

1. Status quo and actual production level of ironmaking

The results of detail survey are shown in the Tables from 2-1 to 2-4. Only one blast furnace is working , the other two blast furnaces are shut down at present. The annual production of pig iron varies from 36,000 to 43,000 tons. Luuxa steelworks has a plan of operating three blast furnaces in the future.

2. The points at issue

(1) Luuxa works No.2 blast furnace produces 100～120 tons/day of pig iron. The productivity of blast furnace is 1.0～1.2 ton/day/m^3.
The productivity is low in comparison with that of modern blast furnace.
(2) The fuel ratio (1180 kg/t-pig) is very high in comparison with that of other countries which is about 500 kg/t-pig. The high fuel ratio is caused by the low blast temperature, high ash content of coke and high slag volume. The gas utilization ratio ($CO_2/(CO+CO_2)$=27～33%) is also low.
(3) All pig iron is cast as mold pig iron at casthouse. One half of the mold pig iron is used for steel making, another half is used for foundry pig iron. The mold pig iron for steel making should be charged directly to the electric arc furnace. The heat is lost between iron making and steel making.
(4) The Si content of pig iron for steel making does not need over 1.25%. The lower Si content is suitable for steel making because of the decrease of desiliconization material.
(5) The slag basicity (CaO/SiO_2) is high and Al_2O_3 content is high. The high viscosity of slag is presumed. The permeability of blast furnace is getting worse for that reason.
(6) The pig iron is cast and treated by workers. If the blast furnace productivity is improved, the casting work may not be finished within the present tap interval.
(7) The coke sample was examined in Japan. The results are shown in the Tables from 2-5 to 2-8.
- The ash content is very high.
- The pore ratio is the same as that of Japanese coke.
- The micro strength index is the same as that of Japanese coke.
- The JIS reactivity is very high.
- The ash composition is the same as that of Japanese coke.
- The coke strength (DI: Drum index) is very low.

- The coke strength after reaction (CSR) is very low.

(8) The ore sample was examined in Japan.
The results are shown in Tables 2-9 and 2-10.
- The lower size ore contains much gangue matter.
- Al_2O_3/SiO_2 is contained much in the gangue matter.
- The large size ore quality is good. The quality is ranked between magnetite and hematite.
- The JIS reducibility is 40%, less than hematite.
- The decrepitation is no problem.

(9) Blast furnace equipment
- No.2 blast furnace adopts the combination of cooling plate and stave cooler.
- Chamotte and high Al_2O_3 are adopted for the shaft brick.
- Chamotte and high $Al_2O_3$are adopted for the hearth brick.

3. Rehabilitation plan and suggestion for the ironmaking area

(1) Increase of productivity
The increase of blast furnace productivity is needed to decrease fuel ratio by means of coke and ore quality improvement and raising blast temperature.

(a) Coke quality improvement
- The coal preparation process should be strengthened to remove ash.
- The partial use of imported coking coal for coking property improvement.

The following effects will be got by these measures besides the productivity increase.
- Coke strength improvement

After the coke strength is improved, the blast temperature will be able to maintain at high level.
- The improvement of blast furnace submaterials consumption.
- The decrease of blast furnace fuel ratio.

(b) Ore quality improvement
- The removal of adhesive fine particle

The fine particle adheres to large size ore. After removal of adhesive fine particle, the blast furnace permeability will be improved and the blast volume can be increased.
- The removal of high gangue matter particle (yellow particle).

The yellow particle contains little ferrous. The yellow particle is able to be removed using the magnetic separator.
After removal of yellow particle, the slag volume of blast furnace will decrease.

(2) Molten pig iron charge to electric arc furnace (EAF)
The direct charge of molten pig iron to EAF is recommended. But the EAF is distant from blast furnace. Then the molten pig iron temperature drops. The heat retention measure is needed, for example heat retention cover of pig iron ladle.

(3) Blast furnace equipment improvement
From the long life and good operation points of view, two suggestions are shown as follows.

(a) Adoption of carbon brick for hearth wall
The carbon brick has high thermal conductivity and is proof against molten pig iron.

(b) Adoption of all stave cooler for furnace body

Table 2-1 No.2 blast furnace specification

	Unit	Figure	Set	Remarks
Blast furnace	m^3	100	3	No.2 blast furnace working No.1,3 blast furnaces shutdown
No.2 BF				First operating date: 29th Nov. '63 China made
Tuyere			6	
Tap hole			1	
Cinder notch			2	
Profile	m			Diameter: Throat 2.5, belly 3.55 Hearth 2.75 Height: Throat 1.5, Shaft 6.35, Belly 1.5 Bosh 2.8, Bosh～Tuyere 0.433 Tuyere～Tap hole 1.132 Tap hole～Bottom 0.302
Cooling				Upper: Cooling plate Lower: Stave cooler Hearth: Spray cooling
Charging equip.				Bell, Skip
Number of bins				Ore 10, Coke 2, Other 5
Hot blast stove			3	Cowper type with inside combustion chamber Maximum blast temperature: 850℃
Gas cleaning				Capacity: 1800 Nm^3/min
Slag treatment				Ladle car 50% Granulated 50%

Table 2-2 Operational results (Present average value)

	Unit	Present value and remarks	
Production	ton/month	3,000 ~ 3,600	
	ton/day	100 ~ 120	
Fuel Coke ratio	kg/t	1,180	
Blast Volume	Nm^3/t	220 ~ 240	
Pressure	g/cm^2	750 ~ 850	
Temperature	℃	750 ~ 850	
Top gas Pressure	g/cm^2	350 ~ 450	
Temperature	℃	< 400	
CO	%	28 ~ 32	
CO_2	%	12 ~ 14	
N_2	%	56 ~ 62	
H_2	%	< 1	
Pig iron		For foundry iron	For steelmaking
Temperature	℃	1350	1300
C	%	3.8 ~ 4.2	4.0 ~ 4.2
Si	%	1.25 ~ 3.25	1.25 <
Mn	%	1.3 <	3.5 <
P	%	0.20 <	0.22 <
S	%	0.6 <	0.07 <
		Casting iron weight 20kg	
		Iron quantity of 1 tap : about 10 ton	
Slag		For foundry iron	For steelmaking
Volume	kg/t	450	400
SiO_2	%	28 ~ 30	30 ~ 32
CaO	%	38 ~ 41	37 ~ 39
Al_2O_3	%	14 ~ 17	14 ~ 18
MgO	%	7 ~ 8	7 ~ 8
CaO/SiO_2		1.35 ~ 1.45	1.30 ~ 1.40
Charging		For foundry iron	For steelmaking
		Magnetite	Limonite
Ore base	ton/charge	1.1 ~ 1.3	1.2 ~ 1.6
Coke base	ton/charge	0.650	0.650
Ore/Coke		1.5 ~ 2.0	2.0 ~ 2.2

Table 2-3 Ore quality

	Unit	Present value and Remarks	
Chemical composition		Magnetite	Limonite
T.Fe	%	59 ~ 64	53 ~ 64
FeO	%	9 ~ 10	5 ~ 6
SiO_2	%	0.5 ~ 1.5	1.0 ~ 1.2
CaO	%	1.0 ~ 1.5	1.0 ~ 2.0
Al_2O_3	%	--	
MnO	%	1.0 ~ 1.5	2.0 ~ 3.0
S	%	0.01 ~ 0.05	0.01 ~ 0.05
Zn	%	0.01 ~ 0.05	0.01 ~ 0.05
Pb	%	0.05 ~ 0.06	0.08 ~ 0.12
Size distribution		Small	Large
	mm	0 ~ 25	25 ~ 50
~ 5	%	5	
5 ~ 10	%	10	
10 ~ 15	%	20	
15 ~ 20	%	25	
20 ~ 25	%	30	5
25 ~ 30	%	10	25
30 ~ 40	%		30
40 ~ 50	%		35
50 ~	%		5

Table 2-4 Coke quality

	Unit	Present value and Remarks				
Coke analysis						
Ash	%	20~25				
Volatile matter	%	<1.0				
Fixed carbon	%	20~26				
S	%	1.5~1.7				
Ash analysis						
SiO_2	%	40~45				
Al_2O_3	%	18~25				
T.Fe	%	18~25				
CaO	%	5~8				
MgO	%	2~4				
Size distribution	mm	~25	~30	~50	~75	75~
	%	20	20	30	20	10

Table 2-5 Coke properties (1)

Proximate analysis (%)			Ultimate analysis (%)				
VM	Ash	TS	C	H	N	S	O
1.13	21.25	1.02	76.64	0.10	1.02	0.95	0.05

Table 2-6 Coke properties (2)

True density	Apparent density	Porosity	Micro-strength	JIS reactivity
g/cm^3	g/cm^3	%	(-)	%
2.10	1.09	48.1	66.22	44.3

Table 2-7 Ash analysis

SiO_2	Al_2O_3	Fe_2O_3	TiO_2	CaO	MgO	P_2O_5	MnO	SO_3	K_2O	Na_2O
55.98	24.94	9.05	1.14	3.81	1.17	0.38	0.06	2.45	0.46	0.07

Table 2-8 Coke strength

DI_{15}^{150}	CRI	CSR
72～73	45.4	16.3

Table 2-9 Comparison of size distribution of iron ores before and after washing

Size(mm)		-0.045	-0.063	-0.125	-0.25	-0.50	-1.0	-2.0	-2.8
Mass ratio (%)	Before	0.0	0.3	0.5	0.3	0.4	0.7	2.6	2.1
	After	3.2	0.7	0.9	0.6	0.5	0.7	2.5	1.8
Adhering ratio (%)		-	-	-	-	-	-	2.0	15.0

Size(mm)		-4.75	-8.0	-9.5	-13.2	-16.0	-19.0	+19.0
Mass ratio (%)	Before	6.2	40.4	17.1	20.5	5.7	3.2	0.0
	After	5.8	40.1	15.6	18.9	5.5	3.2	0.0
Adhering ratio (%)		6.7	7.5	8.7	7.6	3.9	2.0	-

Table 2-10 Classification of iron ores used at Luuxa steelworks according to their appearance after washing

Size	Black and massive	Black and rough surface	Yellow
4.75 - 8.0 mm	57.9 mass %	36.9 mass %	5.2 mass %
8.0 - 9.5 mm	44.6	51.1	4.3
9.5 - 13.2 mm	44.7	53.0	2.2
13.2 - 16.0 mm	56.1	43.9	0.0

Section 3 Steelmaking Operation

Contents

1. The status quo of plant equipment

The present situation of existing plants was investigated by oral interview and some data submitted by VSC during the 1st and 2nd survey.
The rehabilitation plans are discussed and suggested hereinafter.

1.1 Production capacity estimation of existing steelmaking plants

(1) The nominal production capacity is approx. 290 x10^3t/y, and the actual capacity is assumed to be approx. 400 x10^3t/y considering over charged ton/ht and actual tap to tap time. Actual production is approx. 300 x10^3t/y in 1995 (partially '96 data). Table 3-1 shows EAF capacity of existing steelmaking plants.

Table 3-1 EAF capacity of existing steelmaking plants

Works	Nominal		Actual			Actual production
	Equip. x unit	Prod. cap.	Equip. x unit	Tap-Tap	Prod. cap.	1995
	t/ht	x10^3t/y	OC t/ht	hr	t/ht	x10^3t/y
Luu Xa	30 x 1	54.0	30~35 x 1	3.5	60.0	('96) 42.0
Gia Sang	6 x 4	45.0	9 x 4	3.0	63.0	60.0
Da Nang St.	1.5 x 2	5.4	2.3 x 2	(1.5~)2.5	12.0	7.5
Bien Hoa St.	20 x 1	36.0	22 x 1	2hr 10min	60.0	50
Thu Duc St.	12 x 1 8 x 1	21.6 14.4	16 x 1 10 x 1	3.0	32.0 20.0	35
Nah Be St.	12 x 1 10 x 1	40.0	16 x 2	3hr 15min	60.0	('96) 43.0
Tan Thuan St.	3 x 1 (3 x 2) (1 x 1)	5.4 (Alloy) (Alloy)	3 x 1 (3 x 2) (1 x 1)	3.0	6.0	5.4
Tan Binh St.	10 x1	18.0	12~14 x 1	3.0	27.0	23.5
Mechanical Engineering	8 x 1 5 x 1 1.5 x 4	34.2	8 x 1 5 x 1 1.5 x 4	3.0	40.0	34.2
Average	8.2 x 20	15	--	--	--	--
Total	--	289.0	--	--	398.0	300.6

Note: 1) Nominal Capacity = (Nominal t/ht) x 6 (ht/d) x 300 (d/y); The calculation formula is suggested by SSC.
2) Actual capacity =(Over charged t/ht) x 24 x 365 x 0.70/T-T(hr)

(2) The shortage of scrap is one of the limiting factors of EAF production capacity. Generating amount of scrap in Viet Nam seems to be different by region. Scrap is relatively easy to procure in the southern region, but in the northern region it is comparatively difficult to collect domestic scrap timely according to the EAF operation program.

(3) The nominal capacity of continuous casting is approx. 330×10^3t/y, and that of CC+Ingot is assumed to be approx. 480×10^3t/y as shown in Table 3-2.

Table 3-2 Continuous casting & ingot casting

Works	CCM	BT－CC		IG	
		Nominal Capacity $\times 10^3$t/y	Actual Product $\times 10^3$t/y	Nominal Capacity $\times 10^3$t/y	Actual Product $\times 10^3$t/y
Luu Xa	4st CC	120.0	5.5('96	－－	36.6
Gia Sang	－－	－－	－－	75.0	－－
Da Nang St.	－－	－－	－－	16.0	－－
Bien Hoa St.	2st CC	70.0	－－	－－	－－
Thu Duc St.	2st CC	70.0	－－	－－	－－
Nah Be St.	2st CC	70.0	13.0	－－	29.5
Tan Thuan St.	－－	－－	－－	12.0	－－
Tan Binh St.	－－	－－	－－	23.0	－－
Mechanical Eng.	－－	－－	－－	20.0	－－
Total	－－	330.0	－－	146.0	－－

(4) The billet is imported instead of scrap, because the price of billet produced from imported scrap is not competitive to imported billet price.
Figure 3-1 shows the non-flat production route in Viet Nam.

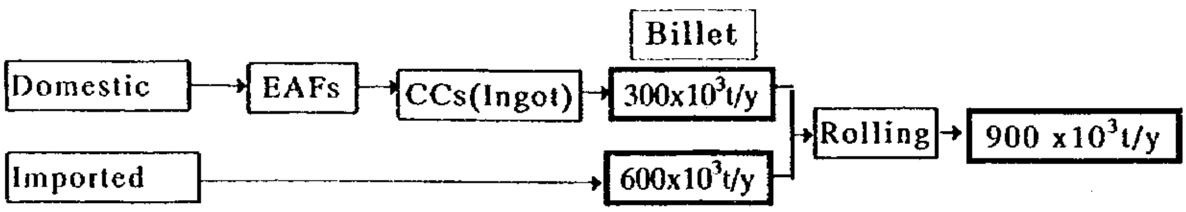


Figure 3-1 The non-flat production route in Viet Nam (product base)

1.2 The present situation and problems of existing steelmaking plants

1.2.1 The production capacity and main specification

Table 3-3, Table 3-4, and Table 3-5 show the characteristics of existing steelmaking plants.

Table 3-3 The average capacity of VSC's steelmaking plants

Number of plants	Number of EAF	Average nominal capacity per EAF	Actual annual capacity per EAF
10	20	8.2 t/ht/EAF	20 $\times 10^3$t/y/EAF

Table 3-4 Equipment of the representative steelmaking plants surveyed

	Luu Xa	Nha Be
EAF	30 t/ht(OC 34t/ht) 16,000 kVA Inner Volume 27.9 m^3	12 t/ht (OC 16t/ht) 9,000 kVA 10 t/ht (OC 16t/ht) 9,000 kVA Inner Volume 16.5 m^3
BT-CCM	100sq. & 120sq. x 4str. Jun. 1996 started Made in India	100sq. x 2str. (at '97 +90 sq. Mold) Dec. 1995 started Made in India
Dust catcher	No (Investment is not planned)	Under construction (June '97)

Note : The data of other steelmaking plants are shown in Table 3-16 and Table 3-17.
OC : Over charged

Table 3-5 Production of the representative plants

		Luu Xa	Nha Be
Actual in 1996		42,120 t/y (50% of capa.) · CC-BT 5,500 (13%) · Ingot 36,600 (87%)	42,500 t/y (94% of capa.) · CC-BT 13,000 (30%) · Ingot 29,500 (70%)
	Plan of CC ratio up	80% Mar. 1997	80% 1997 (mold size increase etc.)
Capacity	(informed)	EAF; 96,000 t/y/furnace CC ; 120,000 t/y	EAF; 45,000 t/y /2 furnace CC ; 70,000 t/y
Working days, ht/M		15 day/M(50%), 96 hts/M	27 day/M(90%), 160 hts/M

The characteristics of the plants are as follows.

a) Small capacity, many furnaces, and located in many places
b) The biggest EAF is 30t/ht, the smallest one is 1.5 t/ht.
c) The reference data of the EAF capacity(t/ht) distribution in Japan is shown in Figure 3-4.

d) It shows that the share of group A (capacity<30t/ht) is approx. 50%, though average capacity of all EAF is approx. 90t/h.
e) The designed capacity is not satisfied at Luu Xa, due to bad domestic scrap.
f) The all EAFs are operated in over charged about 120% of nominal capacity(t/ht). They could not afford to increase the productivity by more heavy charging.

1.2.2 The productivity per worker
Table 3-6 shows the comparison of the productivity between Viet Nam and Japan.

Table 3-6 Comparisons of the productivity

		Luu Xa	Nha Be	Japan
Steelmaking	Persons	140	137	Approx. 80
	Crews x Shift	3 c x 3 s	3 c x 2 s	3c x 3s
	t／person／y	307	313	Approx. 1,000
Production	t/y	43,000	43,000	Approx. 80,000

Note: In case of Japan, the data is average of EAFs capacity <50t/ht.
Referential data is shown in Figure 3-8.
The productivity of Viet Nam is about 1/3 of the small capacity EAFs of Japan.

1.2.3 The amount and quality of scrap generated
a) The scrap is almost domestic obsolete scrap, and the quality is bad.
b) The specific weight is low (0.3～0.5 t/m^3 (Luu Xa)～0.4t/m^3(Nha Be)), and mostly not pre-processed.
c) The low grade quality of scrap causes low productivity and large unit consumption in EAF operation.
d) The amount of obsolete scrap generated domestically restricts the amount of steelmaking production. (approx. $300x10^3$t/y≒Production of EAF)
e) The increase of domestic scrap in 2010 year is not assumed so high, because of low social accumulation in Viet Nam.

1.2.4 EAF／Tap to tap time analyzing
Table 3-7 shows the analyzing of tap to tap time of EAFs.
a) Tap to tap time in Viet Nam is very long(approx. 3.5hr), although it is aimed at decreasing to approx. 2～2.5 hr compared to that of Japan.
b) The reference data of tap to tap time in Japan is shown in Figure 3-7.
The tap to tap time of the smallest size EAF(Group A) is approx. 120min, and that of larger size is approx. 65min.

Table 3-7 Analyzing of tap to tap time of EAFs

	Luu Xa			Nha Be		
		Actual	Aim		Actual	Aim
Tap to Tap time (min)	Scrap charging	21	-	Scrap charging	20	10
	Power on			Power on		
	Melting	130	-	Melting	80	60
	Oxidizing	22	-	Oxidizing	20	15
	Reduction	30	-	Deoxidizing	35	20
	Sampling analyzing		-	Sampling analyzing	10	5
	Tapping	5	-	Tapping	15	5
	Refractory repairing	17	-	Refractory repairing	15	5
	Total	3:45'	2:30'	Total	3:15'	2:00'

1.2.5 Unit consumption (UC)

Table 3-8 shows the unit consumption of major items.

Table 3-8 Unit consumption of major items in Viet Nam

Items	unit	Luu Xa	Nha Be	Japan (A-Group)
Electric power	kWh/t-s	Furnace: 829.0	720～740	Approx. 470
		CC : 27.5 Public : 43.7	154～134	—
Electrode	kg/t-s	10.9	6.41	Approx. 4.7
Oxygen	Nm^3/t-s	No	No	Approx. 22
Carbon blow	kg/t-s	No	No	Approx. 12
Refractory	kg/t-s	Imported from China Roof : 5.0 MgO brick :10 MgO powder :15 Ladle :16 Bottom life : 100 hts	Imported from China Hi-Al_2O_3 : 18.9 MgO : 5.3 Bottom life : 110 hts	Approx. Lining : 2.0 Repair : 3.3 Ladle : 3.0 CC : 0.3
Ferro alloy	kg/t-s	Fe-Mn : 8.30 Fe-Si : 9.21	Fe-Mn : 7.88 Fe-Si : 7.33	Approx. 11.0
CaO	kg/t-s	53 +Dolomite 20	65.0 ～70.0	Approx. 30

a) The data of other steelmaking plants in Viet Nam are shown in Table 3-17.
b) Comparing with the data of small capacity EAF in Japan, the operation indexes of Viet Nam are considerably worse (see Reference data 3.2).

1.2.6 Shortage of billet and expansion plan

a) Table 3-9 shows the demand increase of non-flat product to 2010 based on the market study.

Table 3-9 Steel grade and increasing of non-flat product ($x10^3$t/y)

Year	1996	2000	2005	2010
Non-flat product	910	1,480	2,240	2,870

The existing work's production capacity (approx. $400x10^3$t/y) is too small compared with the total non flat production required.
Drastic improvement of productivity is not expected for the existing plants due to the following reasons.

1) The increase of domestic scrap is not expected so much, and the product by imported scrap is not competitive.
2) The modernized steelmaking plants shall be constructed for the large demand.

b) The expansion program of steelmaking capacity
Table 3-10 and Table 3-11 show the expansion program of steelmaking capacity under planning.
The amount of approx. 1,100 $x10^3$t/y billet shall be produced by the NISW.

Table 3-10 The expansion program of steelmaking capacity

Billet base(final product base)

	Works	Process	Iron source	Product 1996	$x10^3$t/y 2010
Non-flat product	Existing works	Steelmaking	Domestic scrap	(300)	300 (270)
		Rolling	Import BT	(610)	500 (450)
	Joint venture	Steelmaking & rolling	Import scrap	0	1,000 (900) *1)
	ISW	Steelmaking & rolling	Iron ore	0	1,050(950)
	Final product		Import	0	330 (300)
	Total			(910)	3,180(2870)

Table 3-11 The two new billet centers (BTC) under planing

No.	Location	Product	Start up	Process
1.	Cai Lan	500,000t/y	1999± α	EAF+BT/CC
2.	Vung Tau	500,000t/y	1999± α	EAF+BT/CC

1.2.7 The situation of steelmaking (EAF) technology in Viet Nam

The modernizing technologies are not applied yet in Viet Nam as shown in Figure 3-2.

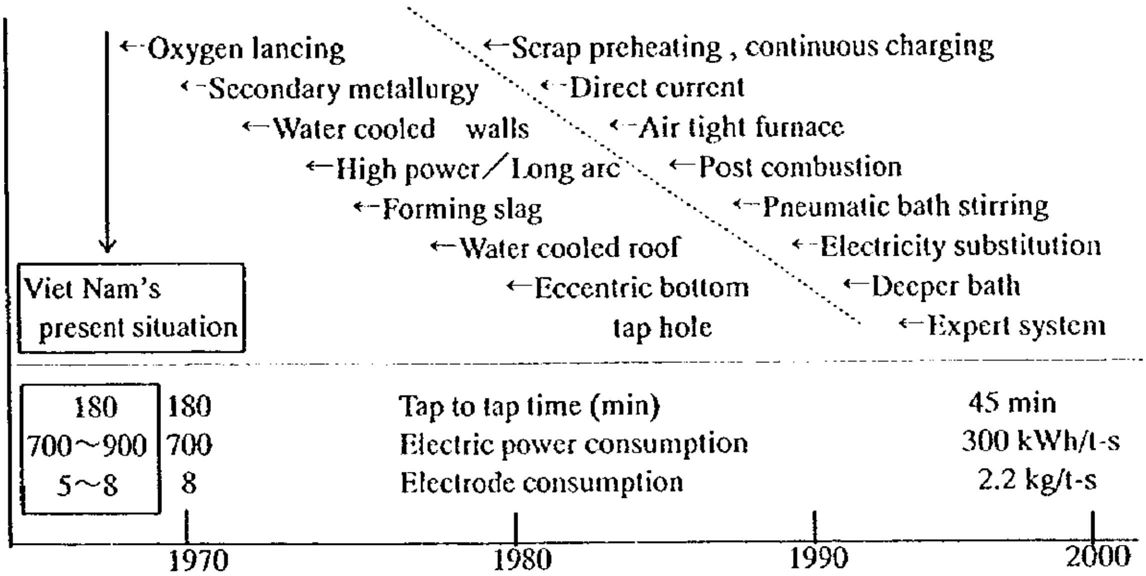


Figure 3-2 Improvements of EAF technologies and situation of Viet Nam (by IISI 27 '93. Henri Faure)

2. Direction of rehabilitation of existing steelmaking plants

2.1 The direction of improvement measures for the existing plants
The modernized technology mentioned above shall be applied as much as possible.

2.1.1 To increase the productivity of EAF
(1) To decrease the tap to tap time
(a) To reduce scrap charging times: approx. Δ 10min.
Table 3-12 shows the scrap charging time and the number of charging frequency.

Table 3-12 Scrap charging time and the number of charging frequency

Plants	Scrap specific weight	Yield CC／IG	Processing	Charging time	Charging frequency
	t/m^3	%	-- --	min/ht	n times/ht
Luu Xa	ca. 0.3~0.5	74／79	No	Approx. 20	4~5
Nha Be	ca. 0.4	89／80	No	Approx. 20	4
Aimed	ca. 0.7	-- --	Yes	Approx. 10	2~3

1) Adoption of scrap processing to increase the specific weight.
2) Being many plants(6)／many EAFs(13) in the southern area, the scrap processing center (cutting and pressing) is effective.
3) In the northern area, the scrap processing center is not so effective because of few plants (few plants(2)／5 EAFs) compared to the southern area.

(b) To reduce the sampling and temperature measuring time; approx. Δ 10min.
Application of the optical analyzing equipment.

(c) To reduce the melting and refining time: approx. Δ 40min(20%)
1) Oxygen and carbon powder blowing equipment shall be applied.
This has already tried in Bien Hoa, and the tap-tap time is reduced from 180 to 140min. This method is planned to introduce at Nha Be and Luu Xa.

(d) To reduce the equipment trouble (Example in Luu Xa) :
1) Electric power is restricted to 70% of the design capacity, because of the electrode breakage at high electric current.
2) Large air pollution because of no dust catcher (investment is not planned).

(e) The reconstruction of larger capacity EAF, and higher power operation:
It is impossible, because of large investment cost is required.

(f) LF Process application: generally 20% reduction; Δ 30min
This is effective for steady operation (chemical composition and temperature adjustment).

(2) Expected tap to tap time
(a) Tap to tap time reduction is expected approximately 60 min. (from 210min. to 150min.).
(b) Approximately, total of 90 min. of reduction is expected by further introduction of LF (from 210min. to 120min.).

2.1.2 To increase the number of sequential casting
Table 3-13 shows the difference of cycle time between EAF and CCM.
The difference is so large to get many sequential casting.

Table 3-13 EAF tap to tap (T-T) time and casting time

Works	EAF (a)			CCM (b)		(a)/(b)
	Capacity (Over charge)	T-T (min)	Matching time (min)	Casting time (min/ht)	BT size & casting speed	
Bien Hoa	20t/ht(22) x 1	130	130 /1 =130	50	110 sq. 2.4 mpm	2.7
Thu Duc	8t/ht(10) x 1 12t/ht(16) x 1	180	180 /2 = 90	25 40 av. 35	110 sq. 2.15 mpm	2.6
Nha Be	12t/ht(16) x 2	195	195 / 2 = 95	40	100 sq. 2.5 mpm	2.4
Luu Xa	30t/ht(35) x 1	210	210/1 = 210	40	110 sq. 2.5 mpm	5.3

(a) The plants having two EAFs are capable of realizing two heats casting sequentially as shown in Figure 3-3.
This method shall be realized soon. (at Nha Be, Thu Duc, Bien Hoa).

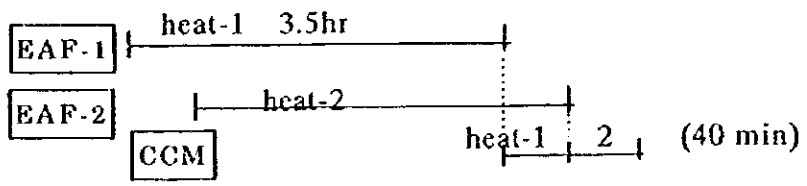


Figure 3-3 Pattern of 2-sequential casting by 2 EAFs

(b) More number of sequential casting requires the following conditions.
1) More decreased tap to tap time shall be required (approx. 120 min.).
2) Number of EAF is 3 or more. (If 3-EAFs are available, at least 3 heats sequential casting is possible.)

Table 3-14 shows the maximum sequential casting ratio according to the number of EAF and tap-to-tap time

Table 3-14 Max. sequential casting ratio

		Tap-to-tap time of each EAF		CC casting time (min)
		>120 min	<120 min	
Number of EAF	1	Max. 1-CCC	Max. 1-CCC	40
	2	Max. 2-CCC	Max. 2-CCC	
	3	Max. 3-CCC	n- CCC continuously	

Note: CCC Continuous continuous casting (=sequence casting)

3) Luu Xa and Gia Sang
They have more difficulty to realize sequential casting than the southern area, because casting time of 4-strand CCM is shorter.

2.1.3 Hot metal charging to EAF (Luu Xa Works)
It is not to be realized because of the following reasons.
a) The temperature of hot metal is too low for carrying and charging to EAF.
b) The construction of the new BF, BOF and CCM is under planning.
- BF 100m^3 x 2 + 15t BOF x 2 + Billet caster
- Capacity 100,000 t/y
- Planned start up to 1999

2.2 Integration of the steelmaking plants

2.2.1 Present plan of SSC

Now(1996) ⇒ 1997

① Bien Hoa: 20t EAF x1 (with rolling mills, higher productivity)⇒ 20t EAF x2

② Tan Binh: 10t EAF x1 (no rolling mill, environmental problem)⇒ to be closed

2.2.2 Suggestions of integration plan
(1) The concept of integration
Table 3-15 shows the plan of integration plan of existing works.
a) To close the small plants with small EAFs, and to construct three EAFs in bigger plants are recommended.
b) The plant integration will exhibit maximum efficiency due to perfect matching between EAFs and CCM.

Table 3.15 The plan of plants integration

Area	Unit	North		Central		South	
		Existing	Future	Existing	Future	Existing	Future
Number of plants		2	1	1	—	6	3
Number of EAF	—	5	2	2	—	13	9
Number of EAF/plant	—	1～4	2	2	—	1～6	3
Average capacity	t/ht	13.2	30	1.5	—	7.5t	14
Production (approx.)	$x10^3$t/y	*1) 120	*2) 150	10.0	0	180.0	300.0

Note: *1) 5 x 13.2 x 24 x 365 x 0.6／3.0 *2) 2 x 30 x 24 x 365 x 0.7／2.5

(2) The concrete plan of integration

a) North area:
Addition of a 30t EAF in Luu Xa Works, small (9t x 4) EAFs of Gia Sang shall be integrated to Luu Xa Works. (The continuous caster in planning now shall be altered.)

b) Central area:
The small EAF(at Da Nang) shall be integrated to the NISW.

c) South area :
- Integration to three big works is proposed, having 3-EAFs and 1-CCM.
- 3-EAFs make sure at least 3-sequential casting.
- More number of sequential casting is possible after decreasing the tap to tap time less than 120 min.

2.2.3 Problems

a) The employment policy: the reemployment of labor at the new steel works
b) Large investment cost: the profit estimation is not studied here.
c) The amount of production depends on the quantity of domestic scrap generation.

2.3 Outline of the present productivity improving plans

Table 3-20 (in Reference data 3.3)shows the investment plan of Nha Be Steelmaking Works and Table 3-21 shows the 5-year investment plan at TISCO (Thai Nguyen Iron and Steel Corporation).

2.4 Summary

2.4.1 The situation of the existing steelmaking plants

(1) EAF

- There are twenty small EAFs in ten steelmaking plants, and the average capacity of them is approx. 8.2 t/ht.
- The production capacity is approx. $300x10^3$t/y, and depends on the domestic generated scrap. The increase of domestic scrap generation is not expectable because of short stock in Viet Nam.
- The operation index is not good compared with that of the modernized EAFs, for example, tap to tap time is 2~3.5 hrs.
- One of the main reasons is the poor quality of scrap (for example, the specific weight is approx. 0.3~0.5 t/m^3).

(2) CCM

- There are four billet CCMs in the four steelmaking plants, and the capacity is 70~$120x10^3$t/y each (Total capacity is approx. $330x10^3$t/y).
- The sequence casting is not realized yet, although two heat sequence casting operation is under trial operation.
- The difference of the operation time (min/ht) between EAF and CCM is too large to do multi-sequence casting operation.

2.4.2 The measures to increase the production capacity

(1) Decreasing tap to tap time from 3.5 hr to 2.5 hr by mainly following ways:

- Improving the specific weight by the construction of scrap pre-treatment centers
- Modernizing the temperature measuring and sampling equipment
- Decreasing the refining time by blowing of oxygen and injection of carbon powder
- Decreasing tap to tap time to approx. 2.0 hr by adoption of LF

(2) Increasing the number of sequence casting by mainly following ways:

- Realizing two sequential casting by 2 EAFs at first
- Integrating the small steelmaking plants to larger efficient steelmaking plants which have 3-EAFs, and realizing multi heats sequential casting

The capacity increase of the existing steelmaking plants shall be expected approx. 40%~50% from the view of tap to tap time decreasing.
However, it is required to improve the production capacity along with the increase of scrap generation which mainly restricts the production of existing plants.

3. Reference data

3.1 The data of steelmaking plants informed at first survey

Table 3-16 The main specification of steelmaking plants of VSC

Plant name	Steel making			
	EAF spec. & capacity	C C or ingot(IG) capacity	Other equipment	Started & future plan
TISCO 1)Luu Xa Steel Works	30t x1 Tr. 16 MVA Capa. 96,000 t/y	4st BT-CC by India Capa. 120,000 t/y IG		'63 started '90~ modernized '94~ 30t EAF
2) Gia Sang Steel Works	6t x4 Tr. 5.2 MVA Capa. 50,00 t/y	IG 75,000 t/y		'75 started '85 EAF started
Da Nang Steel Factory	1.5t x2 Tr. 1.25MVA Capa. 16,000 t/y	IG 16,000 t/y		'92 started
Bien Hoa Steel Works	20t x1 Tr. 12.5MVA Capa. 50,000t/y	2str. BT-CC by China Capa. 70,000 t/y IG; t/y	Oxygen + Carbon Dust catcher by(India)	'69 started LF (idea only)
Thu Duc Steel Works	8t x1 Tr. 6 MVA 12t x1 Tr. 6.5 MVA Capa. 45,000t/y *	2str. BT-CC by China Capa. 70,000 t/y IG t/y	Oxygen + Carbon Dust catcher by(India)	'64 started '75 EAF started '94 CC started
Nha Be Steel Works	12t x1 Tr. 9 MVA 10t x1 Tr. 9 MVA Capa. 45,000t/y *	2str. BT-CC by India Capa. 70,000 t/y IG t/y	Oxygen + carbon	'73 started '95 CC started '97Dust catcher start
Tan Thuan Steel Works	3t x1 Tr. 4 MVA Capa. 12,000 t/y x2 Tr. 2MVA x1 Tr. 1MVA 3t/h Cupola	IG 12,000 t/y	Fe-Si 2,500t/y CaC_2 1,200t/y Pig Iron 1,800t/y	'75 started
Tan Binh Steel Works	10t x1 Tr. 4 MVA Capa. 23,000 t/y	IG 23,000 t/y		'73 started at '97 close
Mechanical Engineering Factory	8t x1 Tr. 6 MVA 5t x1 Tr. 4 MVA 1.5t x1 Tr. 1.5 MVA Capa. 20,000 t/y 2.5t Cupola	IG 20,000 t/y	Cast. 2,800t/y Other; mechanical processing; 1,500t/y	
Total	357,000 t/y	CC 330,000 t/y IG (146,000)		CC 500,000 k/y

Mark (*): The average capacity of EAF without information is assumed as next calculation.
(over charged t/ht) x1440x 365 x 0.6／(tap to tap min)
Work time ratio assumed by the information of SSC is as follows.
(Normal t/ht) x 6(ht/d) x 300(d/y) Tap to tap=3hr ⇒ Work time ratio=0.6

Table 3-17 The main operation indices of steelmaking plants

Plants	Steel making		Employment
	EAF	C C	Persons
TISCO 1)Luu Xa Steel Works	T-T time: 2.5~3.5 hr UC El. Power: 750~830kWh/t Electrode: 7.5~8.0kg/t Scrap: 1.33~1.14 t/t	Casting speed: max. 2.2 av. 2.5 mpm Sq. casting: 1 hts/cast BO ratio : nearly 0	Total: 13,000 (Luu Xa + G.S+Infra) Steel making: 400
2) Gia sang Steel Works	T-T time: 3.0 hr UC El. Power: kWh/t Electrode kg/t Scrap: t/t	----	Total: Steel making: (included in Luu Xa)
Da Nang Steel Factory	T-T time: 1.5~2.5 hr UC El. Power: 1,000 kWh/t Electrode: 8.0 kg/t Scrap: 1.35 t/t	----	Total: 220 (include. RM etc.) EAF: 69
Bien Hoa Steel Works	T-T time: 2 hr 10 min UC El. Power: 700 kWh/t Electrode: 5.0 kg/t Scrap: 1.25 t/t	Casting speed: max.3 av. 2.4 mpm Sq. casting: 1 hts/cast BO ratio: nearly 0	Total: 700 (include. RM etc.) Steel making: 201
Thu Duc Steel Works	T-T time: 3.0 hr UC El. Power: 900 kWh/t Electrode: 6.0 kg/t Scrap: 1.4 t/t	Casting speed: max. 3 av. 2.15 mpm Sq. casting: 1 hts/cast BO ratio: nearly 0	Total: 600 (include. RM etc.) Steel making: 120
Nha Be Steel Works	T-T time: 2hr 35 min UC El. Power: 780 kWh/t Electrode: 5.5 kg/t Scrap: 1.18 t/t	Casting Speed: 4.0 max. av. 2.5 mpm Sq. casting: 1 hts/cast BO ratio: a few times	Total: 580 (include. RM etc.) Steel making: 170
Tan Thuan Steel Works	T-T time: -- hr UC El. Power: 850 kWh/t IG (Fe-Si: 8,000, CaC: 3,000 t/y)	----	Total: 380 (include Fe-Si, RM and cupola) Streelmaking: --
Tan Binh Steel Works	T-T time: 3.0 hr UC El. Power: 910 kWh/t Electrode: 8.02 kg/t Scrap: 1.49 t/t	----	Total: 300 (without RM)
Mechanical Engineering Factory	T-T time: -- hr UC El. Power: -- kWh/t Electrode: -- kg/t Scrap: -- t/t	----	Total: 450

Comments: The some data of Luu Xa and Nha Be Steel Plants are different from those informed at the second survey.

Note: BO ratio; break out ratio

3.2 The reference data of EAF operation in case of Japan (Data : Jan.~Dec. 1995)

(1) Number of existing EAF — Figure 3-4
The small EAF group (A) is applied to special steel manufacturing plants.
The capacity for carbon-steel is large (group B~D).

(2) Nominal capacity of existing EAF — Figure 3-5
The average capacity of Group-A is approx. 24 t/ht, it is larger than that of Viet Nam.

(3) Yield of existing EAF(CC) — Figure 3-6

(4) Tap to tap time — Figure 3-7

(5) Productivity — Figure 3-8

(6) Other typical unit consumption

Table 3-18 and 3-19 show the reference data of EAF in Japan for example.

Table 3-18 UC of electric power, electrode, oxygen, carbon

Group		Unit consumption			
		Electric power	Electrode	Oxygen	Carbon
	t/ht	kWh/t	kg/t	Nm^3/t	kg/t
A	<30	469	4.7	22	–
B	30~50	431	2.2	24	–
C	50~100	392	2.1	34	–
D	>100	363	1.7	28	–
Average		380	1.9	29	12

Table 3-19 Main materials, sub-materials, and refractory

Gr.	Main		Sub -material			
	Pig ratio	Ferro Alloy	CaO	$CaCO_3$	Carbon	Other
	%	kg/t	kg/t	kg/t	kg/t	kg/t
Average	12.2	11	26	1	13	4

Gr.	Refractory						
	Roof	Wall	Bottom	Repair	Ladle	CC	Total
	kg/t	kg/t	kg/t	kg/t	kg/t	kg/t	kg/t
Average	0.1	0.5	1.2	3.3	3.0	0.3	8.4

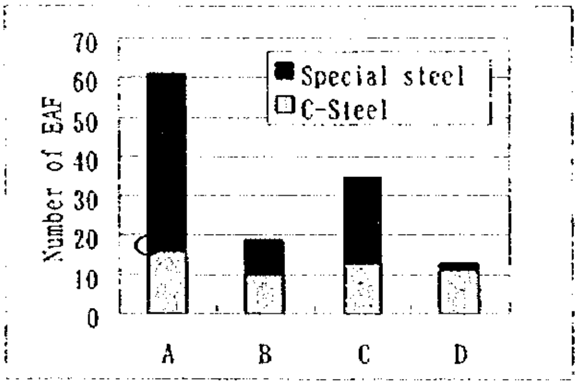


Figure 3-4 Number of EAF

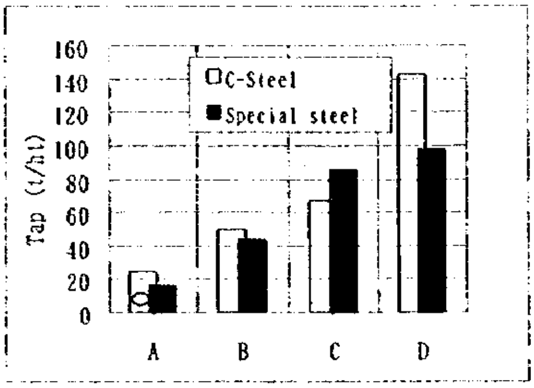


Figure 3-5 Nominal capacity of EAF

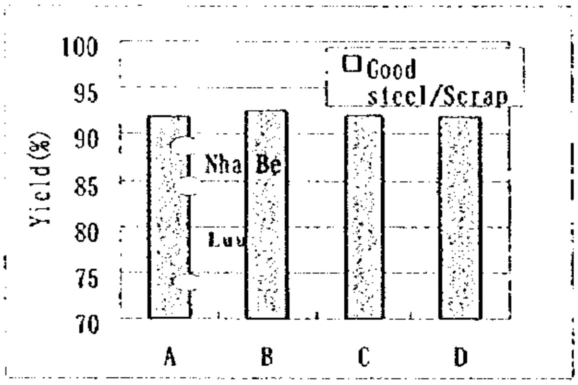


Figure 3-6 Yield of existing EAF

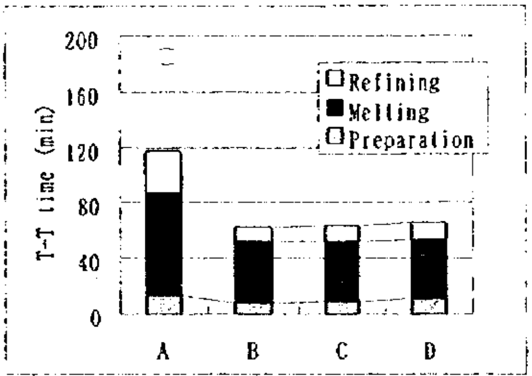


Figure 3-7 Tap to tap time (min)

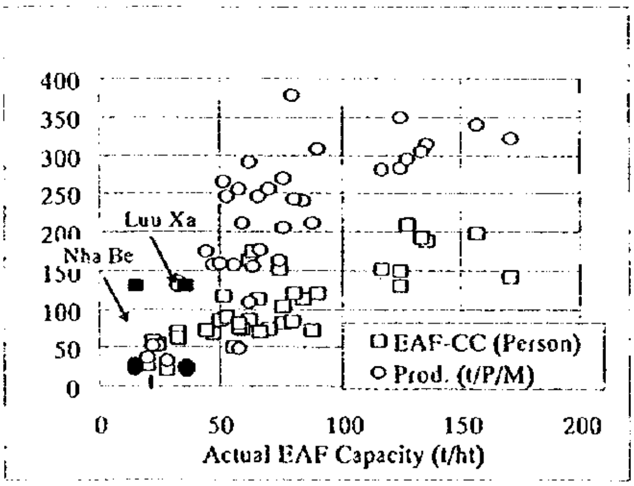


Figure 3-8 Productivity

Mark ○ ; Data of Viet Nam

Group	Capacity (t/ht)
A	<30
B	30-50
C	50-100
D	>100

3.3 Outline of the present productivity improving plan and investment plan

Table 3-20 shows the outline of the present productivity improving plans in Nha Be Steelmaking Works.

Table 3-20 Outline of improving plans of Nha Be Steelmaking Works

	Now	Investment	Remarks
Scrap quality	Bad	Not improved	Not satisfied
Demand	Low	Increased(assumed)	Depend upon domestic scrap
O_2	No	Under planning	
C blow	No	Under planning	
Ton/heat	16	16	Impossible
LF	No	No	Low profit by SSC's F/S
Secondary refining	No	No	
Dust catcher	No	Under construction	'97 May complete $M 0.6

Table 3-21 shows the outline of the present investment plans in TISCO.

Table 3-21 TISCO's 5-year investment plan (1996 – 2000 year)

Works	Item	Timing	Investment MVND ($M)
Luu Xa	Rod mill 6 & 8 mm φ to be added to medium section mill	'96-'97	30,000 (2.35) India ODA
Luu Xa	LD converter	'98-'99	20,000 (1.8) Import
Gia Sang	Rod Mill	'96	6,000 (0.55)Domestic
Gia Sang	CC machine	'98-'99	18,000 (1.6) Import
Hai Phong	EAF 6t/ht	'96	5,750 (0.5) Local bank credit, Local made
	Lang Cam & Phan Me Coking mine	'96-2000	36,000 (3.3)
	Flux and Additive mines Exp.		14,000 (1.3)
	Others · Heat treatment facilities · Scrap cutting & briquetting · Chemical analysis & quality · Rehabilitation of sinter plant · Office & Social welfare	'96-2000	31,750 (2.9)
	Total		161,525 (13.5)