No. 3

JAPAN INTERNATIONAL COOPERATION AGENCY [JICA]

MINISTRY OF INDUSTRY, TRADE AND TOURISM
THE REPUBLIC OF HUNGARY

THE FEASIBILITY STUDY ON THE FACILITY IMPROVEMENT AND ENVIRONMENTAL PROTECTION OF BORSOD POWER PLANT IN THE REPUBLIC OF HUNGARY

FINAL REPORT

Main Report

August 1997

PACIFIC CONSULTANTS INTERNATIONAL, TOKYO
in association with
JAPAN ENVIRONMENT ASSESSMENT CENTER CO., LTD., TOKYO

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In this report, project costs are estimated based on January 1997 prices with an exchange rate of 1US$ = HUF 161.06 (=¥116.65).

PREFACE

In response to a request from the Government of the Republic of Hungary, the Government of Japan decided to conduct the Feasibility Study on the Facility Improvement and Environmental Protection of Borsod Power Plant in the Republic of Hungary and entrusted the study to Japan International Cooperation Agency (JICA).

JICA sent a study team, led by Dr. Akira Uchida of Pacific Consultants International (PCI) and organized by PCI and Japan Environment Assessment Center Co., Ltd., to the Republic of Hungary four times from March 1996 to May 1997.

The team held discussions with the officials concerned of the Government of the Republic of Hungary, 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 promotion of the plan 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 Republic of Hungary for their close cooperation throughout the study.

August 1997

Kimio FUJITA
President
Japan International Cooperation Agency

August 1997

Mr. Kimio Fujita
President
Japan International Cooperation Agency

LETTER OF TRANSMITTAL

Dear Sir,

We are pleased to submit to you the final report entitled "The Feasibility Study on the Facility Improvement and Environmental Protection of Borsod Power Plant in the Republic of Hungary." This report has been prepared by the Study Team in accordance with the contracts signed on 2 February 1996, 15 May 1996, and 9 May 1997 between Japan International Cooperation Agency (JICA) and Pacific Consultants International (PCI).

This Study aims at improvements of power and heat generating facilities and environmental protection measures in Borsod Power Plant, where the plant efficiency has decreased due to superannuated facilities, and environmental problems have been growing mainly due to large amount of air pollutant emissions. The study included the construction of a new 150 MW power generation unit within the existing site and the renovation of some of existing facilities for continuing supply of about 240 MW of heat to the surrounding area.

This report presents an optimal reconstruction plan to achieve above aims. The plan has been formulated through surveys, analyses, and assessment on the aspects of technology, environment, economy and finance. The studies concerning the new unit incorporated the result of the past feasibility study conducted by the Hungarian authority with necessary modifications. For enabling utilization of Hungarian brown coals while satisfying the air pollutant emission standards, the type of a boiler for the new unit was selected to be of circulating fluidized bed combustion. For the renovation of existing facilities, it was proposed that four out of ten 100 t/h boilers of the pulverized combustion type be converted to the natural gas combustion type.

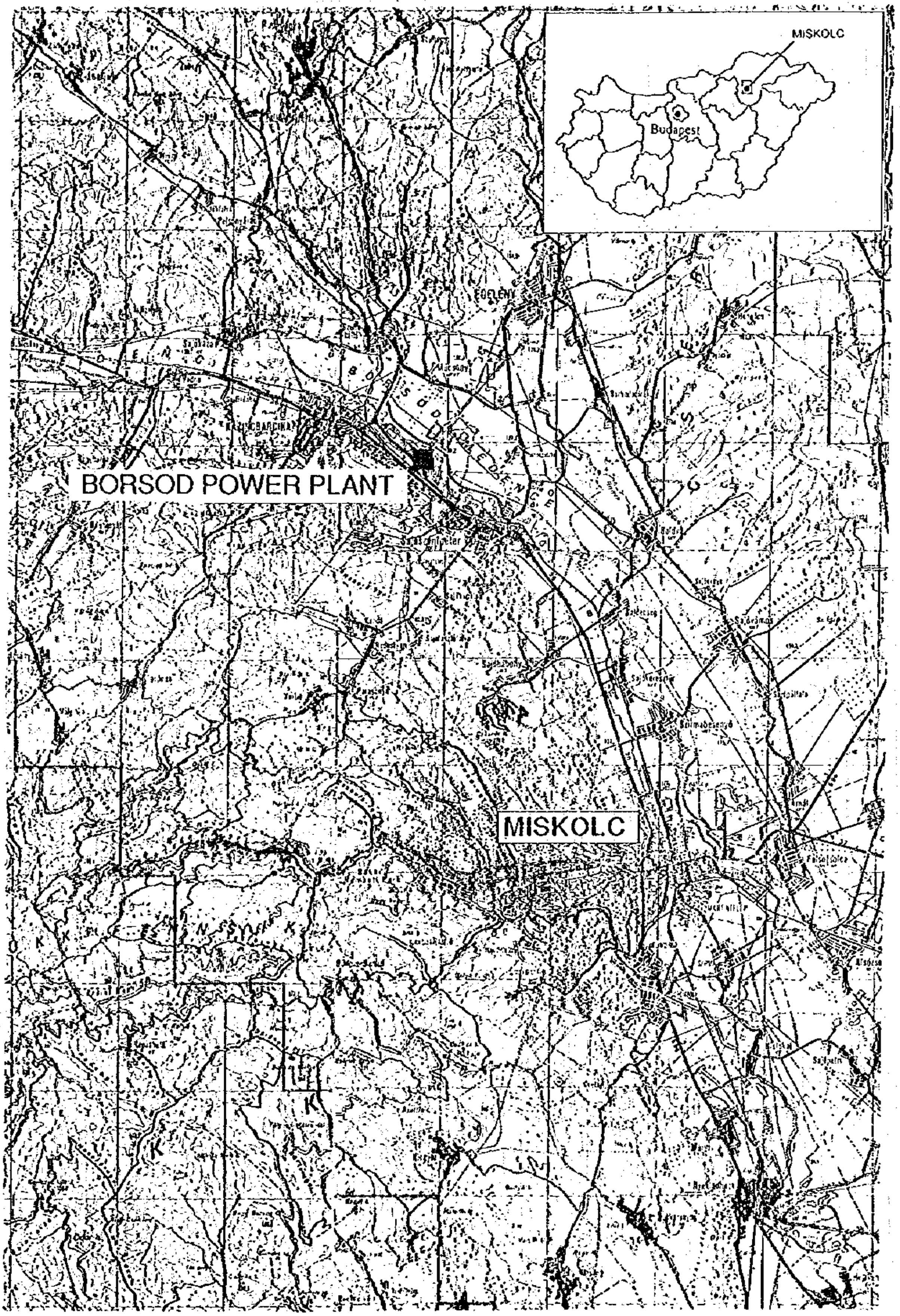
We wish to express grateful acknowledgments to your Agency, Ministry of Foreign Affairs, and Ministry of International Trade and Industry. We also wish to express our sincere appreciation to Hungarian agencies concerned including the Ministry of Industry, Trade and Tourism, Ministry for Environment and Regional Policy, Hungarian Power Companies, Ltd. and Borsod Power Plant, who extended utmost cooperation to the Team. Finally, we acknowledge our deep gratitude to the Embassy of Japan in Hungary and JICA Austria Office for their variable suggestions and assistance.

Yours faithfully,

内田 顕

Akira Uchida
Team Leader

LOCATION MAP



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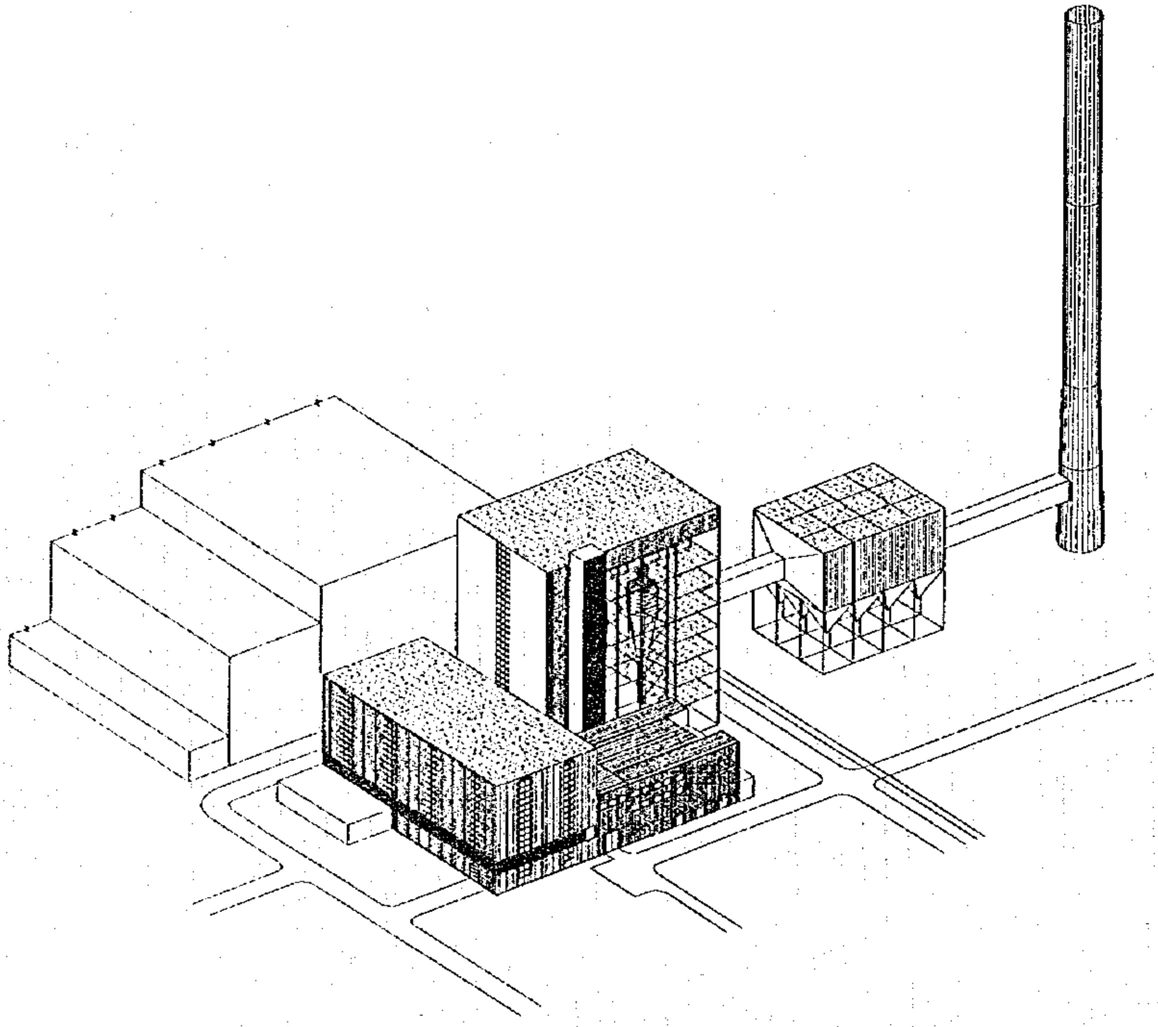
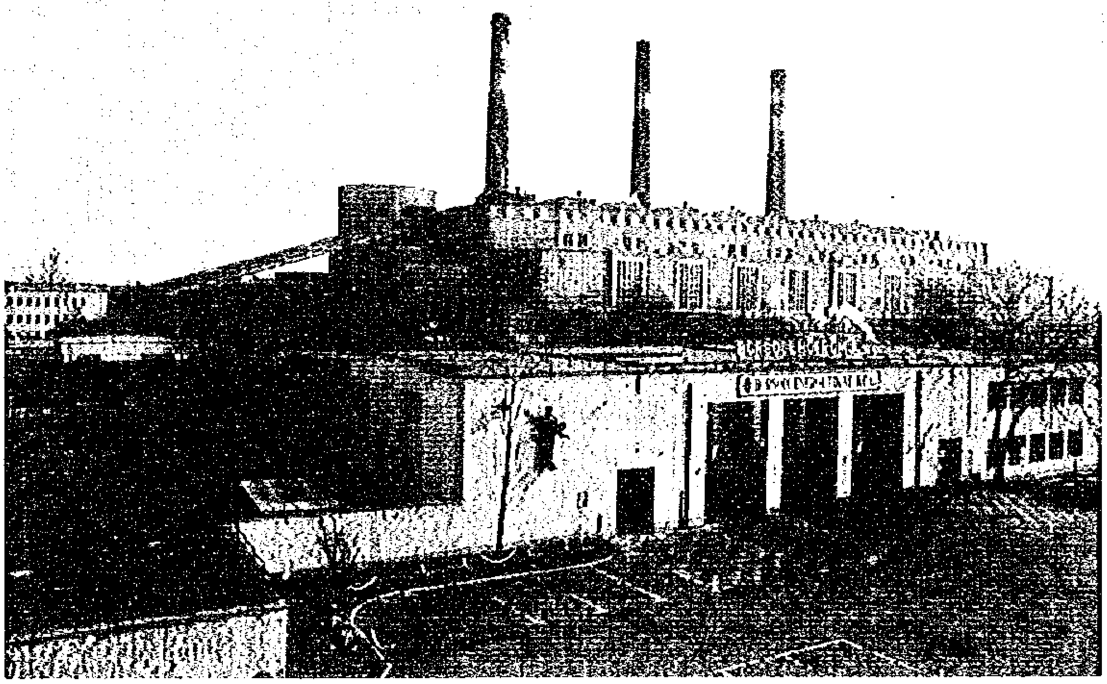
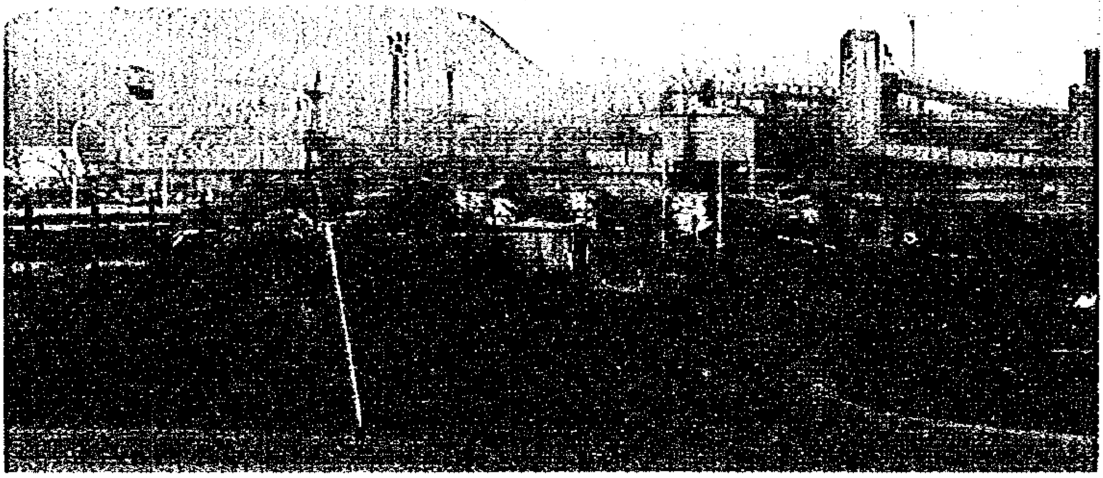


The New 150 MW Unit

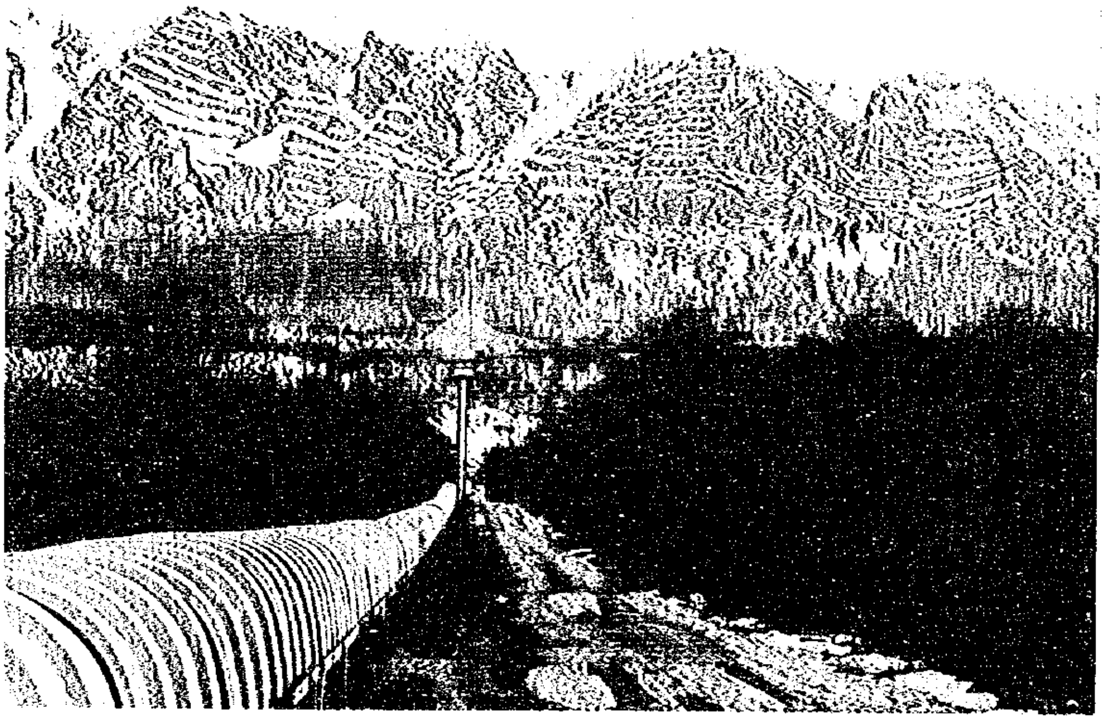


The Whole View of Borsod Power Plant

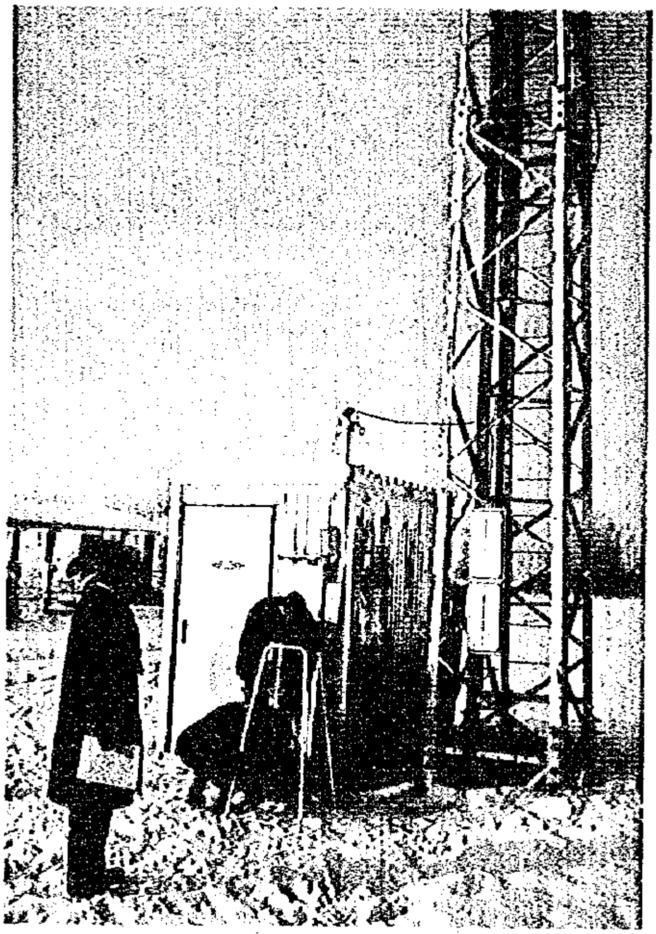
Thick Slurry Pipeline and Slag Area



Lyukobanya Coal Mine

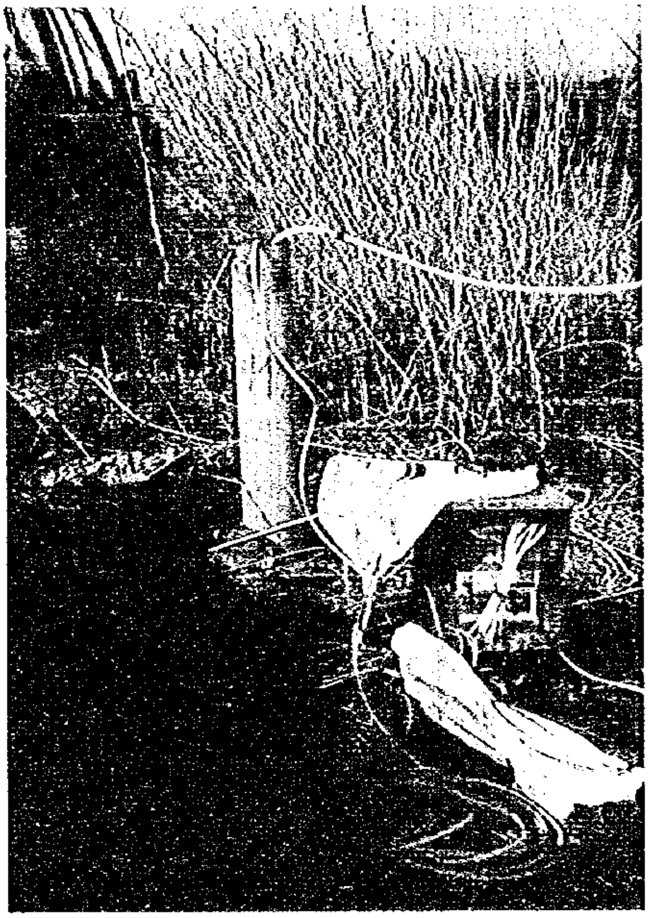


Limestone Mine (BCM)

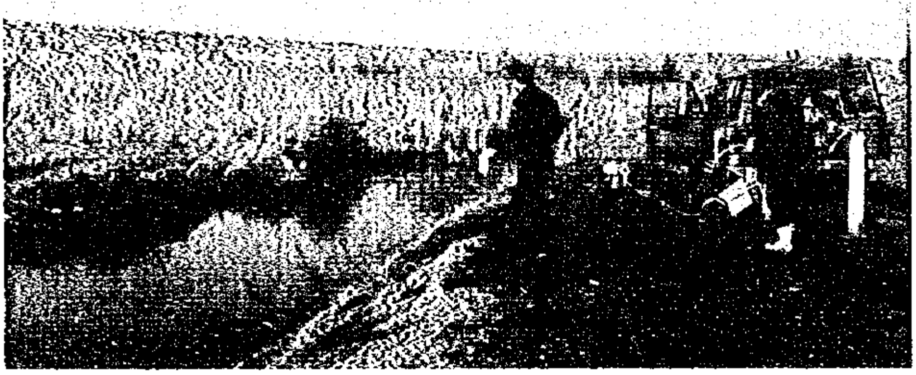


Ambient Air Measurement at Station No. J1

Soil Sampling



Ground Water Sampling at TM 41



Surface Water Sampling at Szuha River

The Feasibility Study on the Facility Improvement and Environmental Protection of Borsod Power Plant

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Abbreviations

Name of Organization

ANTSZ	:	National Public Health and Medical Officer's Service
EGI	:	A consultant firm which prepared the F/S report for the new 150MW unit in Borsod Power Plant
EKF	:	North Hungarian Environmental Protection Inspectorate
EPA	:	The U. S. Environmental Protection Agency
ERV	:	A Hungarian consultant firm for power plant
GRW	:	A former East-German company which made most of Hungarian control systems
IKIM	:	Ministry of Industry, Trade and Tourism
KTM	:	Ministry for Environment and Regional Policy
MHD	:	Hungarian Ship and Crane Works (Magyar Hajó- és Darugyár)
MOL	:	Hungarian Oil Company
MÁV	:	Hungarian National Railways
MVM	:	Hungarian Power Companies, Ltd.
OMH	:	National Office of Measurements
OVIT	:	National Power Grid Company, Ltd.
TOP	:	National Fire Service Headquarters

Technical Terms

AH or A/H	:	Air preheater
ANK-K	:	Cross-coil type analogue, indicator type device
ANNUBAR	:	A type of probe for measurement
ARA	:	Amsterdam, Rotterdam, Antwerp ports
BFB(C)	:	Bubbling fluidized bed (combustion)
BG	:	Background concentration
BOD	:	Biochemical oxygen demand
BWK	:	Full heat power (Brennstoff Warme Kraft)
Btu	:	British thermal unit
C/V	:	Calorific value
CFB(C)	:	Circulating fluidized bed (combustion)
CIF	:	Cost, insurance, freight
COD	:	Chemical oxygen demand
DCIS	:	Distributed control and information system

DO	:	Dissolved oxygen
ECO	:	Economizer
EGR or FGR	:	Exhaust gas recirculation or flue gas recirculation
EMU	:	Signal converter to get mA signals
EP or ESP	:	Electrostatic precipitator
FB(C)	:	Fluidized bed (combustion)
FDF	:	Forced draft fan
FGD	:	Flue gas desulfurization
FOB	:	Free on board
F/S	:	Feasibility study
GEP	:	Good engineering practice
GL	:	Ground level
GSA	:	Gas suspension absorption
HDPE	:	High density polyethylene
HFB(C)	:	Hybrid fluidized bed (combustion)
Hh	:	Gross heat value (calorific value)
Hl	:	Net heat value (calorific value)
ICFB	:	Internal circulating fluidized bed
IDF	:	Induced draft fan
M	:	Molar concentration
MCR	:	Maximum continuous rating
MSZ	:	Hungarian Standards
ND	:	Not detected; analytical data below a limit of detection
Nm^3	:	Gas volume at the normal condition ; 0 ℃ and 1 atmospheric pressure
O & M	:	Operation and maintenance
Org-	:	Organic
PCF	:	Pulverized coal firing
PE	:	Polyethylene
PFB(C)	:	Pressurized fluidized bed (combustion)
PLC	:	Programmable logical controller
PSU	:	Process system unit
RC	:	Reinforced concrete
RH	:	Reheater
RLS-II	:	A type of PID regulator, compact design of GRW
SCR	:	Selective catalytic reduction
SH	:	Superheater
SPM	:	Suspended particulate matter
SS	:	Suspended solids/ Stainless steel

TC	:	Thermocouple
UPS	:	Uninterrupted power supply
dB	:	deci-Bell; unit for noise level
mBf	:	above the Baltic Sea level
nc	:	Normal condition
p-Alkali or p-value	:	Phenolphthalein alkalinity
tce	:	Ton coal equivalent
μ S/cm or mS/cm	:	Micro Siemens per centimeter; unit for conductivity

Conclusions and Recommendations

1. Conclusions

This Study aims to develop an optimal plan for reconstruction of Borsod Power Plant and to verify the feasibility of the plan from the technological and economic view points. The plan includes: 1) construction of a new power generation unit of 150 MW capacity which utilizes local brown coal to the maximum possible and satisfies the environmental regulations, and 2) renovation of several of existing boilers for heat supply while satisfying the environmental regulations.

Based on the study and evaluation of the plan from the technological, environmental, economic and financial aspects, it is concluded that the reconstruction plan is feasible. Conclusions are explained below.

(1) Electric Power Demand

Although the electric power demand in Hungary continually decreased from 1989 to 1993 due to the industrial recession, the demand has gradually increased thereafter.

While the total electricity consumption in 1995 was 36.5 TWh, the demand in 2010 is projected to be in a range of 43.3 - 49.3 TWh. Thus, the electricity demand is expected to increase steadily in the future even with the most pessimistic scenario.

(2) Power Generation Capacity

The commissioned total power generation capacity in 1995 was about 7,400 MW, of which thermal power units accounted for 74 %, nuclear power units 25 %, and hydraulic power units 0.6 %. Most of the existing thermal power generation units are old with poor efficiency, and are not able to meet the environmental requirements equivalent to those of EU countries, that will be in force from 2005. Accordingly, they should be replaced or substantially renovated.

(3) Utilization of Domestic Coals

Through the national energy policy, coal mines in vicinity of power plants have been managerially integrated into the power plants, and other coal mines have been closed or are in the process of closure since they are economically no longer viable. The power plant companies having coal mines need to utilize their own coal, while implementing sufficient environmental protection measures. Borsod Power Plant is one of such power plants.

(4) Reconstruction Plan of Borsod Power Plant

The reconstruction plan of Borsod Power Plant is summarized below. For the part of the new 150 MW unit, the result of feasibility studies conducted until 1993 by MVM was utilized to the maximum extent, and modifications were made as necessary.

1) New unit

Main parameters

Electric power output	: 150 MW
Steam generation	: 460 t/h
Fuels to be used	: Borsod brown coal and imported coal (50 % - 50 % in heat equivalent)

Expected pollutant concentrations in the exhaust gas:

SO_2: 400 mg/Nm^3

NOx: 200 mg/Nm^3

Dust: 50 mg/Nm^3

Annual plant utilization rate : 68 % (6,000 hrs/y)

Major facilities

Boiler	: Circulating fluidized bed (CFB) boiler with external heat exchanger (EHE)
Electrostatic precipitator	
Steam turbine	: 3-casing tandem compound double flow (TCDF) reheat type
Generator	: Three-phase synchro-generater with static excitation, of lateral positioned, cylindrical, rotating field, anti-explosion type structure
Stack	: 130 m height

Feed water facilities
Cooling tower
Coal handling system
Limestone handling system
Slag and fly ash handling system
Transformers
Control and instrumentation system

2) Renovation of existing facilities

Main parameters

Peak heat demand	:	29 bar steam	:	120 MW
		15 bar steam	:	9 MW
		6 bar steam	:	34 MW
		Hot water	:	78 MW
		Total	:	241 MW

Annual heat demand : 2,780 TJ/y

Major renovation works

Boilers : Four out of ten existing pulverized coal combustion boilers (100 t/h each) are converted to the gas/oil combustion type. Burners, control system, flue gas recirculation ducts and fans are newly installed, and economizers and air preheaters are readjusted.

Turbines : In addition to use of some of existing turbines with appropriate repairing, one unit of 32 MW double extraction condensing turbine is installed.

(5) Environmental Impact Assessment and Environmental Protection Measures

1) Result of environmental impact assessment

Air quality

Predictions of ambient SO_2 concentration for short-term and heating season average indicate that the SO_2 concentrations would exceed the environmental standards to be enforced in 2005 at certain locations even when the Power Plant satisfies the emission standards of SO_2. Control measures for other sources are necessary to satisfy the environmental standards. Predicted ambient concentrations of NOx satisfy the environmental standards.

The result of down-wash analysis indicates that, with a stack height of 125 m (original plan), the ground-level concentration of SO_2 is elevated by the down-wash phenomenon.

A prediction of SO_2 concentration under stagnant condition indicates that the contribution of the Power Plant to the point of the highest concentration is 85 μg/m³ or 32 ppb. A substantial improvement will be brought about by Plant reconstruction. The environmental standard of 30 minutes average for protected areas II (400 μg/m³ or 150 ppb) is satisfied. The background concentration (contribution from other sources) itself exceeds the environmental standard for protected areas I (250 μg/m³ or 94 ppb).

Groundwater

Additional groundwater pollution by sludge disposal can be completely prevented by application of the impermeable sheet method. The groundwater flow velocity in the concerned area is estimated to be 0.42 m/day, meaning that it takes some 40 years for the whole body of presently polluted water to reach the well of Borsodszirak I/A for drinking water. It is estimated to take about 50 years for the quality of the groundwater to recover to the level of the drinking water protection standard.

Soil

By implementing dust control of flue gases and treatment of acid/alkali waste liquids, additional soil pollution can be prevented. The recovery of soil already polluted is expected only through natural purification processes, except for highly polluted particular spots where specific measures should be taken.

2) Environmental protection measures

Air quality

- Adoption of a CFB boiler for the new unit, and conversion of 4 existing boilers from the pulverized coal-firing type to the gas-firing type
- The height of the stack of the new unit to be changed from 125 m (original plan) to 130 m to prevent down-wash
- Soil covering and planting of the existing sludge storage area to prevent coal ash scattering

Groundwater and soil

- Sludge is transported through pipeline and stored within the basins of impermeable sheet to prevent groundwater pollution completely

- Wastewater from the water treatment plant is neutralized, diluted by mixing with other wastewater to meet the effluent standards, and discharged to Sajó River and public sewer system

River water

Cooling water is recycled in the closed system to avoid thermal water discharge to Sajó River so that the river ecology is not disturbed.

3) Environmental monitoring plan

- Adequate monitoring during the construction period to minimize environmental impacts

- Environmental monitoring after the start of the plant operation

  a) flue gas monitoring

  b) ambient air quality monitoring

  c) establishment of a continuous monitoring network by integrating items a) and b)

  d) groundwater monitoring

  e) regular monitoring of wastewater, noise, traffic volume, etc.

(6) Cost and Period of Reconstruction

Periods and cost of the plant reconstruction are as follows:

	Construction period	Construction cost (1,000 US$)		
		Foreign currency	Local currency	Total
New unit	5 years	53,830	102,127	155,957
Facility renovation	3 years	6,960	39,863	46,823

Note: Includes custom duties.

(7) Economic and Financial Analyses

1) Economic analysis

The environmental quality of the area including air quality is expected to be improved through the implementation of the reconstruction plan. It is most desirable in the economic evaluation to quantify such environmental improvements as the benefit of the reconstruction project. However, since methods of quantifying such benefit in economic term have not been established, the alternative project approach has been adopted in the economic evaluation.

For the new unit, the alternative facility to the proposed CFB boiler was selected to be the pulverized coal combustion boiler with wet-type flue gas desulfurizer. For the facility renovation, the alternative to the proposed boiler conversion into gas-firing type was determined to be the addition of semi-dry type flue gas desulfurizers to the present pulverized coal combustion boilers. In both the new unit project and the facility renovation project, the proposed project was found to be superior to the alternative project in the economic evaluation.

2) Financial analysis

Since the new unit and the renovated facilities are to be operated in a cooperative manner, the financial analysis was made on the whole project with these two components combined.

With the income of selling electricity and heat against the investment costs (construction, operation and maintenance), the financial internal rate of return (FIRR) was calculated to be 17.4 %, amply exceeding the adopted loan interest rate (8.2 %).

2. Recommendations

(1) Power Plant Development

In this Study for the reconstruction of Borsod Power Plant, there are some elements that can be referred to in planning reconstruction of other power plants of the similar nature in Hungary. With such consideration, the following are recommended.

1) Power plants in Hungary attached with coal mines are faced with two themes in performing the role of power supply: a) to utilize their own coal thereby also contributing to regional employment, and b) to satisfy more and more stringent environmental protection requirements. To select economical and most appropriate

technology to realize the above, various technologies available in the world should be broadly reviewed and their experience should be carefully fed back in application.

2) There are only several commercially operated power plants in the world that employ the CFBC technology, and each one is operated under unique conditions. None of them is using coal of low quality similar to Hungarian brown coal. Therefore, utmost care should be taken in boiler design and fuel supply plan.

3) There have been number of cases of forced outage with operation of CFBC boilers due to troubles associated with handling of combustion residue. Therefore, it is most desirable to minimize the amount of combustion residue. This requires that the fuel supply plan be established in such a way that the ash content and the sulfur content of coal fuel are kept below certain levels.

4) Since development of a power plant requires a large sum of capital investment, the success of the project depends much on the conditions of procuring the funds. Funds for private-base development projects are generally procured from commercial banks. However, for projects having high public interest, there are cases where public funds of international and/or foreign governmental loan institutions are available under certain conditions. Such possibilities should be pursued by communicating with these institutions.

(2) Environment

1) Observation of regulations and standards

By implementing the reconstruction plan as proposed, Borsod Power Plant will be able to satisfy the new emission standards to be effected on January 1, 2005. But the ambient air quality standards are difficult to be met unless suitable measures are taken for other air pollution sources including coal heated residences.

2) Environmental protection

The Plant intends to prevent groundwater pollution by coal ash by means of the thick-sludge technology alone in the future. Validity of this technology should be proven prior to the start of operation of the new unit. It is not recommended at the present stage to utilize salt-containing effluent from the water treatment plant as part of thick-sludge transport water.

Future environmental protection measures should be concerned not only with prevention and reduction of environmental impacts, but recovery of the natural environment, creation of semi-natural environments, and landscaping.

3) Environmental monitoring

Presently, the responsibility of environment-related monitoring is administratively divided to Regional Environmental Protection Inspectorates (for source monitoring) and Regional Institutes of Public Health and Medical Officer's Service (for environmental monitoring). It is recommended that these functions be integrated so that prompt actions can be taken concerning environmental protection.

Proper operation and maintenance of monitoring equipment should be secured by appropriation of sufficient funds.

4) Environmental management organization of the power plant

In order to strengthen the environmental management functions of the Power Plant, an environmental management committee should be organized supported by sub-committees and charged with environmental affairs, energy saving, disaster prevention, etc., each planning and facilitating implementation of concerned measures.

Chapter 1

Introduction

Chapter 1 Introduction

1.1 Background of the Study

(1) Electric Power Organization

As the Hungarian economic system has been proceeding to market economy, the energy sector was reorganized during the last half of 1991 to 1992, and the energy tariff system was revised. Hungarian Power Companies Trust (MVMT) was reorganized as Hungarian Power Companies, Ltd. (MVM), a state share-holding company. Eight power generation companies, one power transmission company, and six power distribution companies belonged to the MVM group.

(2) Electric Power Demand

By 1993, the electricity demand in Hungary became lower by 16 % in comparison with that in 1989. This was due to the industrial stagnation accompanied with the transition to market economic system. The electricity demand in the following years showed a trend of slight recovery. The recent peak demand of electricity was about 5,700 MW experienced in January 1995. Meanwhile, the electricity demand from households increased by 1.8 times during the 10 year period from 1980 to 1990, although the demand levels in the latest few years are similar. As a whole, the electricity demand is no doubt expected to increase toward future resulting from economic recovery.

(3) Electric Power Supply

Available electric generation capacity in Hungary is about 7,000 MW, of which thermal power accounts for 74 %, nuclear power 25 %, and hydraulic power 0.6 %. In thermal power plants, superannuated, low-efficiency power generation facilities have been shutdown in recent years. In terms of power generation output, Paks Nuclear Power Plant (4 x 440 MW) is continuing smooth base-load operation and generates about 42 % of the national total output (1995). Coal-fired power plants generates about 26 % of the total, and oil/gas-fired power plants generates about 31 % as peak-load plants. In general, thermal power plants in Hungary have problems of decreased efficiency due to superannuation of facilities and difficulties in power supply due to increased price of domestic coals.

(4) Environmental Regulation of Thermal Power Plants

Coal-fired thermal power plants currently operating in Hungary are mostly old and of small capacity and low power generation efficiency. Since they are not equipped with flue gas desulfurizers (FGD), they are large sources of SOx emission. There have been ambient air quality standards, emission standards of stationary air pollution sources, and fining regulations for the pollution sources on the basis of the Environmental Protection Act of 1976. As the new Environmental Protection Act was enacted in May 1995, these environmental regulations and standards have been revised to more stringent ones comparable to those in the EU member countries. Coal-fired power plants, especially, are now urged to take necessary measures for meeting these requirements.

(5) Power Plants in the Sajö Valley Area

In the Sajö Valley area, there is the City of Miskolc which is the third largest city in Hungary with a population of about 200,000 located at about 150 km to the north-east from Budapest. Miskolc and adjacent cities constitute one of major industrial areas in Hungary. The pollution level in the area is also one of the highest in the country due to the activities of heavy and chemical industries, winter-time heating using coal, and automobiles. Among these, 3 power plants, i.e. Tiszapalkonya (Tisza I; 250 MW), Tisza II (860 MW), and Borsod (170 MW), are major sources of air pollutants. The three power plants had been owned and operated by Tisza Power Station Ltd. and its subsidiary Borsod Energetic Ltd.

(6) Borsod Power Plant

Borsod Power Plant was constructed during 1955 - 1957, about 40 years ago. The electric generation capacity is 170 MW, and the heat supply capacity is 220 MW. The plant has 10 boilers and 9 turbines. All the boilers were replaced during 1978 - 1985 except step ways. But the turbines are all original ones and are reaching the service life. Local brown coal used as fuel is of low quality with calorific values of 1,800 - 2,200 kcal/kg and sulfur content of 2 - 3 %. The boilers are equipped with an electrostatic precipitator, but the amount of SOx in the exhaust gas being emitted is far above the emission standard. The plant is also supplying steam and hot water to nearby factories and residences. This is a very important contribution of the plant to the area.

Under such circumstances, MVM formulated a reconstruction plan of Borsod Power Plant in 1993.

(7) Present Study

In May 1994, the Hungarian Government requested the Japanese Government to conduct a feasibility study (F/S) concerning the aforementioned reconstruction plan of

Borsod Power Plant, that could satisfy requirements of international loan institutions. Accordingly, Japan International Cooperation Agency (JICA) dispatched a preparatory study team to Hungary in June and September 1995, and reached to the agreement with the Hungarian Government on the Scope of Work for the present Study. The Study started in February 1996, and the first site work of the Study Team was conducted in March 1996.

1.2 Objectives and Outlines of the Study

(1) Objectives of the Study

The objectives of the Study are:

1) Construction of an efficient new power unit with a capacity of about 150 MW in the site of Borsod Power Plant giving sufficient considerations for the environment

2) Renovation of several number of existing boilers and related facilities in Borsod Power Plant so as to meet the emission standards and to secure the capacity of heat supply to the neighboring area

To fulfill above objectives, an optimum plan for reconstruction of the plant using local brown coal while meeting the emission standards is to be prepared. The feasibility of this plan is to be verified from the technical, economic, financial, and environmental view points.

In conducting the Study, the result of the feasibility studies conducted by EGI, a Hungarian consultant, under the contracts with MVM are to be utilized as much as possible.

Technology transfer is to be made in appropriate areas during the course of the Study.

(2) Study Area

The Study Area is mainly the Borsod Power Plant site in Kazincbarcika located in 20 km north of Miskolc. The surrounding areas environmentally affected by the power plant, and relevant nearby coal mines and business sites are also included as required.

(3) Outline of the Study

The Study was carried out in the following 3 stages:

- Preliminary investigation stage
- Detailed investigation stage
- Feasibility grade design stage

1) Preliminary investigation stage

(a) Preparation for the Study in Japan (collection, review and analysis of existing data, technology transfer planning, etc.)
(b) Collection, review and analysis of relevant data in Hungary
(c) Field reconnaissance
(d) Fuel supply study
(e) Limestone supply study
(f) Study on heat and power supply
(g) Initial environmental examination (IEE)
(h) Study on fluidized bed combustion (FBC) boilers
(i) Study on use of existing infrastructures, facilities and equipment
(j) Study on possibility of local fabrication and installation works
(k) Formulation of concrete study policy based on the above studies

2) Detailed investigation stage

(a) Detailed analysis of the existing F/S reports
(b) Identification of points at issue for environmenal impact study considering the resolution of EKF
(c) Identification of points at issue for optimum power plant development program
(d) Investigation of topography, geology and hydrology
(e) Environmental survey (emission and ambient concentration of air pollutants in exhaust gas, groundwater and surface soil quality, etc.)
(f) Environmental impact study
(g) Preparation of optimum power plant development program (new unit and renovation of existing units)
(h) Technology transfer seminar

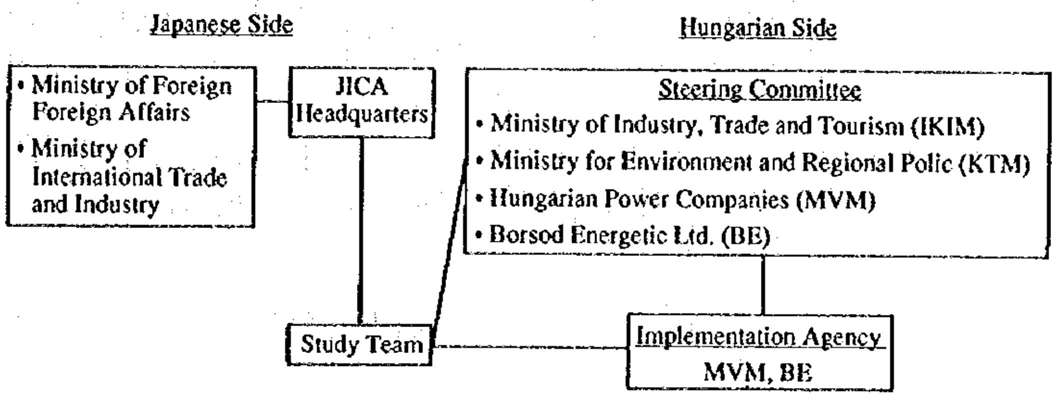
3) Feasibility grade design stage

(a) Preliminary design
(b) Construction planning
(c) Cost estimation
(d) Economic and financial analysis

1.3 Organization for the Study

(1) General Organization

The general organization for the Study is as shown below.



(2) Organization of the Study Team

The members of the Study Team are as follows:

Name	Field in Charge	Company
Dr. UCHIDA Akira	Leader	PCI
Mr. KANEKIYO Masao	Deputy Leader/Power Generation Facility (Environmental Protection)	JEAC
Dr. James D. REGAN	Ditto	JEAC
Mr. SATO Akio	Power Generation Facility (General/New & Existing Turbines)	PCI
Mr. ROZGONYI Pál	Power Generation Facility (New Boiler)	Transverticum
Mr. VOLTAY Géza	Power Generation Facility (Existing Boiler)	Transverticum
Mr. NÉMEDI József	Power Generation Facility (Electric Instrumentation and Control)	Transverticum
Mr. SZANATI Sándor	Electric Substation	Transverticum
Mr. KATSUTA Motoji	Fuel Planning/Environmental Investigation	JEAC
Mr. HIRAO Minoru	Environmental Investigation	JEAC
Mr. FUKASE Kazuo	Civil Engineering and Architectural Facilities	PCI
Mr. MAEDA Eiji	Economic and Financial Analysis	OPMAC
Mr. OGURA Toru	Environmental Protection	JEACI
Mr. KOJIMA Satoshi	Work Coordination	PCI

Note: PCI : Pacific Consultants International Co., Ltd.
JEAC : Japan Environment Assessment Center Co.,Ltd.
OPMAC : Overseas Project Management Consultants Co.,Ltd.
JEACI : JEAC International Co.,Ltd.

The assignment for Deputy Leader / Power Generation Facility (Environmental Protection) was changed from Mr. KANEKIYO to Dr. REGAN in October 1996.

(3) Hungarian Organization

The responsible agencies of the Hungarian Government for the Study are the Ministry of Industry, Trade and Tourism (IKIM) and the Ministry for Environment and Regional Policy (KTM). IKIM is the primary coordinating agency.

The implementing agencies are Hungarian Power Companies (MVM) and Borsod Energetic Company (BE). The Steering Committee was established by participating all of these agencies.

The members of the Steering Committee and Counterpart to the Study Team are as follows.

<u>Steering Committee</u>

Ms. FEKETE Ildikó	IKM
Mr. RAKICS Róbert	KTM
Ms. CSOKNYAI Istvánné	KTM
Mr. CIVIN Vilmos	MVM
Mr. LUZSA György	MVM
Mr. SZABÓ János	MVM
Mr. Richard Mardon	AES
Mr. NÉGYESSY István	AES-BE

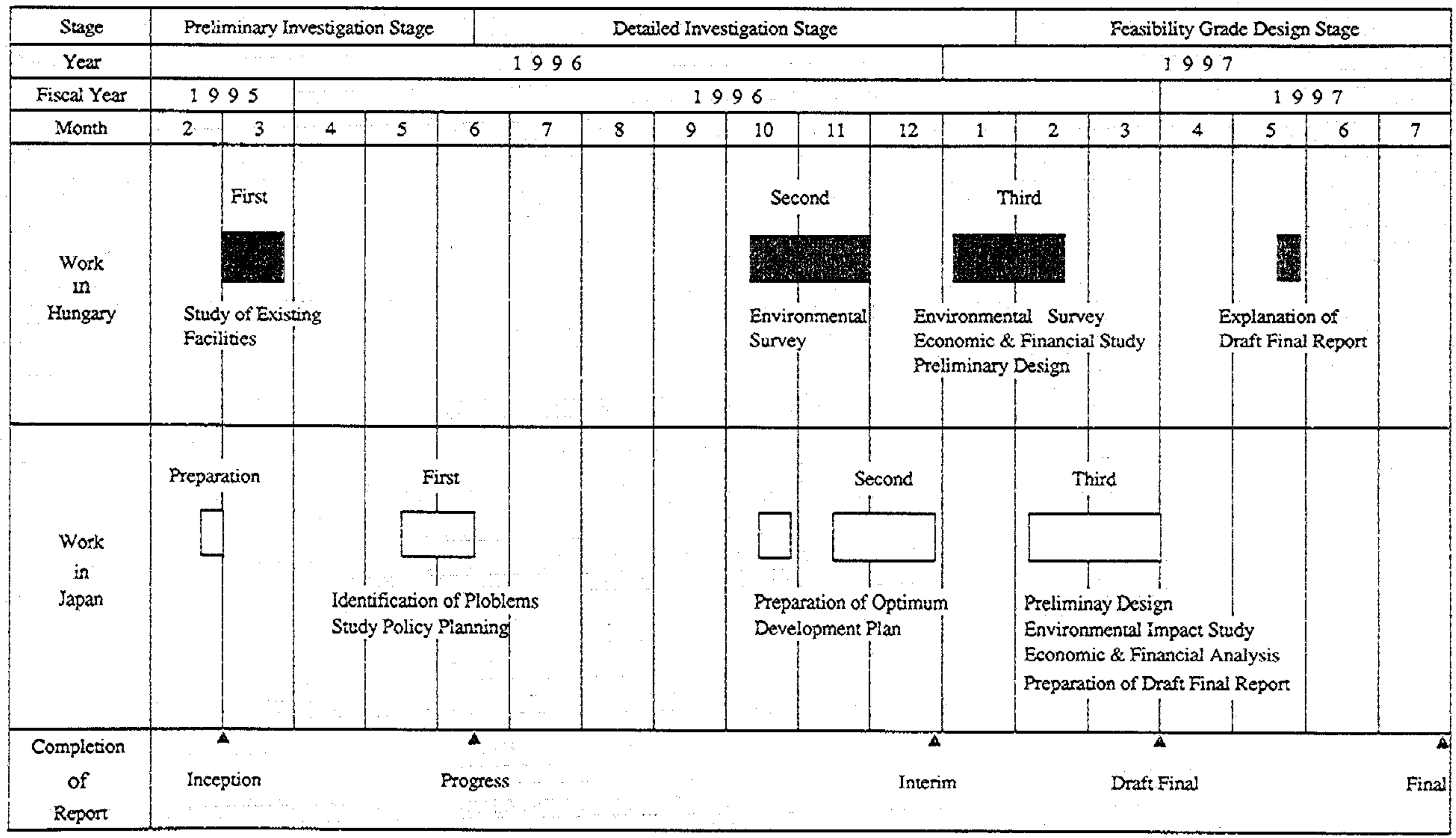
<u>Counterpart Members</u>

Mr. NÉGYESSY István	BE	Counterpart Leader
Mr. KERTÉSZ Mátyás	BE	General Coordination
Mr. TÓTH István	BE	Fuels Planning/Handling/Transportation
Dr. ÁVÉD István	BE	Environmental Protection, Water Treatment Plant
Mr. MÓRICZ József	BE	Boiler
Mr. LUZSA György	MVM	Coordination, Technology
Mr. SZABÓ János	MVM	Environmental Protection
Mr. RAISZ Gyula	EKF	Flue Gas Measurement
Mr. CSABA Kiss	BE	Technology

1.4 Time Schedule of the Study

A general time schedule of the Study is shown in Table 1.4.1.

Table 1.4.1 General Time Schedule of the Study



Chapter 2

Background of the Project

Chapter 2 Background of the Project

2.1 Economic Situation in Hungary

Hungary experimented with market type reforms much earlier than the neighboring socialist countries. The pre-1990 systemic reforms, however, were faced with serious constraints because of the inability to accept private ownership of capital as an essential part of a well functioning market economy.

The major economic indicators since 1990 are shown in Table 2.1.1. In the spring of 1990, a new democratic government came to power to embark on a fully-fledged market economy. A vigorous stabilization program including expenditure cuts and tax increases achieved a successful macroeconomic turnaround and even led to small current account surpluses in 1990 - 1992. But this macroeconomic stabilization was not durable. It did not lead to more rapid growth. Eventually the structural reforms slowed down and failed to address key structural weaknesses.

Table 2.1.1 Major Economic Indicators

Year	1990	1991	1992	1993	1994	1995e	1996f	1997f
Real GDP (HUF billion)	2,836	2,498	2,421	2,406	2,476	2,538	2,576	2,653
% change	-3.5	-11.9	-3.1	-0.6	2.9	2.5	1.5	3.0
GDP deflator % change	26.0	36.4	21.6	21.3	19.5	25.7	22.5	16.8
Goods Exports: volume % change	13.2	28.2	1.0	-14.4	16.6	8.4	5.8	7.2
Goods Imports: volume % change	6.4	64.7	-7.6	19.6	14.5	-4.0	2.1	6.3
Trade Balance ($ million)	348	189	-49	-3,247	-3,635	-2,442	-2,100	-2,200
Current Account Balance	127	267	324	-3,455	-3,911	-2,480	-1,900	-2,100
Convertible Currency External Debt	21,327	22,353	21,627	24,782	28,763	31,713	29,567	30,974
Exchange rate, end period (HUF/$)	61.4	75.6	84.0	100.7	110.7	135.9	160.7	177.9
Nominal effective rate (1990=100)	100.0	86.9	78.4	73.0	62.8	47.9	41.0	35.7
Exchange rate,end-period (Yen/$)	134.4	125.2	124.8	111.9	99.7	103.4	106.0	95.2
Lending rate (%)	28.8	35.2	33.1	25.4	27.4	32.6	-	-
Deposit rate (%)	24.7	30.4	24.4	15.7	20.3	26.1	-	-
$ LIBOR (%)	8.4	6.1	3.9	3.4	5.1	6.1	5.1	4.6

Source : IIF Country Report, June 28, 1996

The new and current government led by the Hungarian Socialist Party, which took power through the election of May 1994, has been pushing ahead with macroeconomic adjustment policy despite the resignation in February 1996 of Finance Minister Lajos Bokros, principal author of the March 1995 stabilization package. Budget cuts and structural reforms initiated under the former Minister have been largely sustained by his successor. Growth in real GDP of 1996 is expected to keep slowing down in response to weaker markets both abroad and at home.

This stabilization package is only a first step; and it must be supplemented by further, concerted reforms that address longstanding weaknesses in the fiscal and incentive framework. Out of many targets to be tackled in their reform program, acceleration of enterprise and bank privatization is considered to be the most pressing element.

The new privatization act enacted in June 1995 broadened the privatization base by reducing the previously-mandated minimum state shareholdings. In the second half of 1995, privatization process accelerated again after stagnant period of the process from 1993 and early 1995. The sale of energy utilities and telecommunications, pharmaceutical and other firms led to record privatization revenues of HUF 450 billion in 1995, equal to about $3.5 billion, of which $3 billion was foreign investment. These sales brought Hungary past the half-way mark of the privatization process. Roughly US$6 billion in state assets remain to be privatized, excluding US$2.4 billion in assets to be held permanently by the state.

2.2 Situation of Energy and Electric Power

2.2.1 Energy and Electric Power Supply Policy

The responsibility for coordination and establishment of the appropriate energy supply policy lies with the Ministry of Industry, Trade and Tourism (IKIM). The main aspects and considerations of the present energy policy of Hungary approved in 1993 are as follows:

- To increase safety of energy supply by means of diversifying import sources and increasing the quantities of energy reserves stored
- To supply energy at lowest possible costs
- To increase the efficiency of energy supply and consumption
- To achieve the above while satisfying environmental protection requirements to a greater extent
- To increase the ratio of utilization of renewable energy sources and resources
- To introduce and satisfy conditions of market economy where the costs of energy production and supply are proportional to energy fees and charges
- To develop laws and regulations corresponding to and harmonized with standards and requirements of European Union

- Publicity and clarity of decisions carried as is customary and appropriate in a democratic society

The Hungarian Government has been strenuously pushing forward the above policies and endeavoring to join the European Union. In the energy sector, most of the legal requirements as a member state of EU have already been incorporated into Hungarian laws.

Corresponding to the enactment of the new Environmental Protection Act in December 1995, regulations and standards concerning the environmental protection and pollution prevention, including emission standards of air pollutants, have been being revised to more stringent ones as comparable to those of the EU countries. In the case of power plants, most of power generation facilities of 7,400 MW in the country will have to be shutdown after 2004 according to these environmental requirements. Therefore, modernization of those facilities are absolutely needed.

Since the enactment of the new Privatization Act in 1995, the Government has been accelerating privatization of state-owned energy-related enterprises. Primary purposes of the Privatization Act in the energy sector are: to rationalize economically the system of energy supply and consumption, and to promote installation of modern facilities that can meet requirements of environmental protection.

By the end of 1995, shares of all the six power distribution companies, two power generation companies, all the five gas supply companies, and the Hungarian Oil and Gas Company (MOL), among the state-owned energy enterprises, were partially sold to private investors who are mostly foreign investors. Privatization processes are still in progress.

As these processes go forward as expected in the electric power sector, all of the seven power generation companies and six power distribution companies of the MVM group will become the independent private companies by the end of 1997. MVM will buy electricity from the power generation companies to accept into the national power grid, and sell it to the power distribution companies. These transactions will be done on the contract basis.

Although a certain portion of shares of MVM is sold to these investors, the Government will remain as the majority share-holder of MVM. And MVM will be the majority share-holder of National Power Grid Company (OVIT) and Paks Nuclear Power Station Company. Such framework of the electric power industry intends to secure the national interests while increasing the efficiency of power generation and its supply.

2.2.2 Demand and Supply of Energy and Electricity

(1) Total Energy Source

Table 2.2.1 and Figure 2.2.1 show the general trend of total energy balance in Hungary for the period from 1985 to 1995. The energy supply total was increasing up to 1985, but it sharply plumped after 1989 due to the severe economic recession. Remaining in the lowest level for three years (1992 - 1994), it took a slight recovery in 1995.

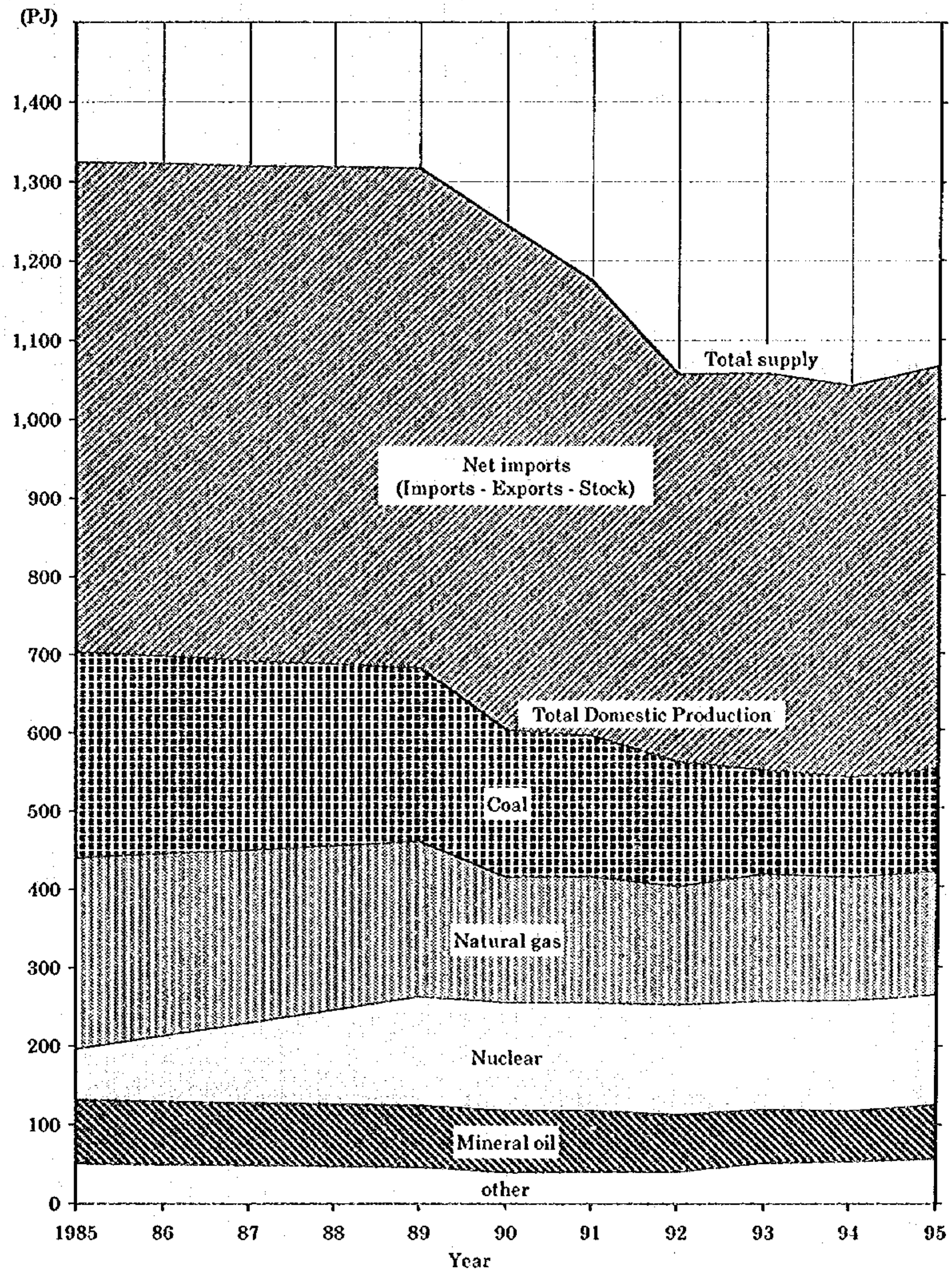
The share of the net import (import-export-stock) in the total supply surpassed 50 % in 1990, but then slightly decreased to 47 - 48 % level afterwards. Import involves petroleum (crude and refined oil) and natural gases as major portion.

Table 2.2.1 Trend in the Total Energy Source Balance

(Unit : PJ)

	1985	1989	1990	1991	1992	1993	1994	1995
Domestic production	703.6	682.7	603.4	596.0	563.1	552.9	543.5	553.9
Coal	263.1	221.7	188.2	180.1	159.1	132.9	128.1	130.1
Mineral oil	80.5	78.2	78.5	77.7	72.5	67.8	64.4	68.4
Mining PB gas	10.5	11.1	10.2	9.8	10.2	10.4	10.4	11.3
Natural gas	244.3	197.7	159.6	160.2	151.3	162.9	157.2	158.6
Gasoline	24.5	20.0	16.1	15.5	16.0	15.9	15.5	16.1
Electricity (nuclear)	64.8	138.9	137.3	137.3	139.6	138.0	140.5	140.3
Electricity (hydro)	1.5	1.6	1.8	2.0	1.6	1.7	1.6	1.6
Firewood	14.4	13.5	11.7	13.4	13.3	13.7	14.0	15.9
Others						10.0	11.5	11.6
Imports	705.3	730.1	724.7	617.0	537.1	597.9	578.1	609.4
Sources total	1,408.8	1,412.8	1,328.1	1,213.0	1,100.9	1,150.8	1,121.6	1,163.3
Exports	66.9	85.3	70.8	49.0	58.7	74.1	91.4	87.5
Change in stocks	+18.0	+11.2	+13.1	-11.0	-14.9	+18.4	-12.4	+8.7
Supply total	1,323.9	1,316.3	1,244.2	1,175.0	1,057.1	1,058.3	1,042.6	1,067.1

Sources : MVM Statistical Data 1994 (April 1995), 1995 (June 1996).
Statistical Yearbook of Hungary 1992, Central Statistical Office, 1993.
Annual Report 1992, National Bank of Hungary, 1993.
The data for 1995 were provided by IKIM.



Source : Drawn from Table 2.2.1

Figure 2.2.1 Trend in the Total Energy Source Balance in Hungary

(2) Electric Power Generation and Consumption

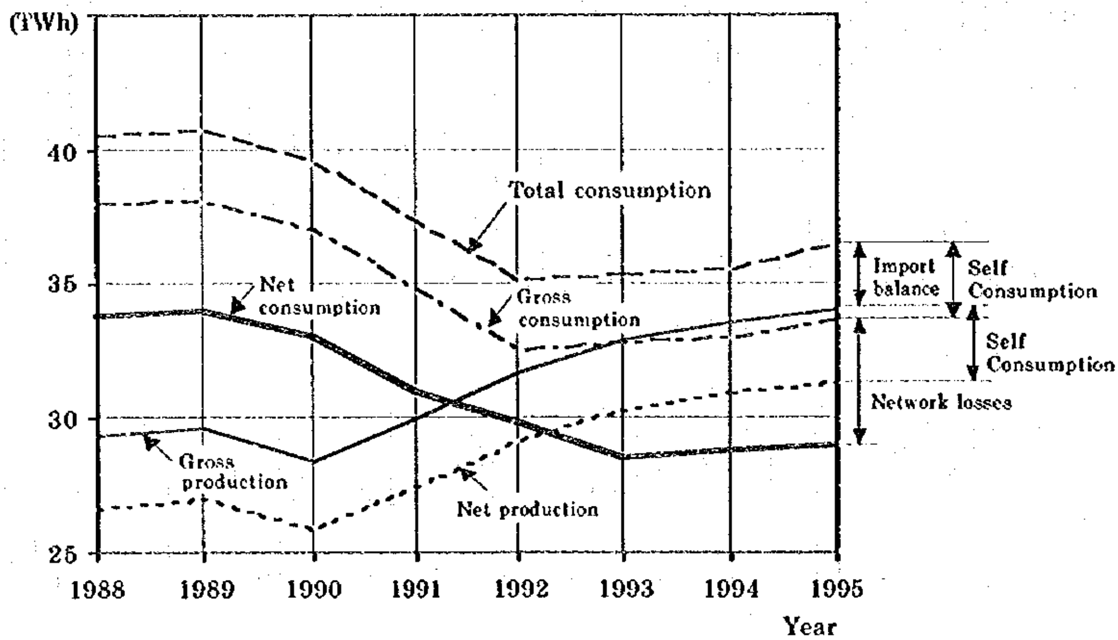
Table 2.2.2 and Figure 2.2.2 show the trend of electric energy production and consumption for the past 8 years in Hungary.

Table 2.2.2 Trend of Electric Energy Production and Consumption

(Unit: TWh)

Year	1988	1989	1990	1991	1992	1993	1994	1995
1. Gross production	29.33	29.58	28.44	29.96	31.69	32.92	33.52	34.04
2. Self consumption of P.P.	2.57	2.60	2.54	2.50	2.57	2.56	2.56	2.75
3. Net production (1 - 2)	26.66	26.98	25.90	27.47	29.12	30.35	30.96	31.29
4. Import balance	11.29	11.08	11.15	7.35	3.47	2.48	2.03	2.41
5. Total consumption (1 + 4)	40.53	40.67	39.58	37.31	35.15	35.39	35.55	36.44
6. Gross consumption (5 - 2)	37.95	38.07	37.05	34.82	32.59	32.83	32.99	33.69
7. Network losses	4.22	4.14	4.04	3.87	2.84	4.36	4.25	4.74
8. Net consumption (6 - 7)	33.74	33.94	33.01	30.95	29.75	28.47	28.74	28.95

Source : MVM Statistical Data 1995, March 1996.



Source : Drawn from Table 2.2.2

Figure 2.2.2 Trend of Electric Energy Production and Consumption

The total consumption decreased continuously from 1989 to 1992, then turned to gradual increase. Power generation (gross production) decreased temporarily in 1990, but is showing constant increase afterwards.

Accordingly, the import balance of electric energy significantly decreased after 1990. The ratio (import balance/total consumption) was as high as 28 % in 1990. But it reached the lowest at 5.7 % in 1994, and remained 6.6 % in 1995.

Out of the gross electricity production at 34.04 TWh in 1995, the power plants of the MVM group produced 33.20 TWh (97.5 %). Table 2.2.3 shows consumption of primary energy by the power plants of the MVM group.

Table 2.2.3 Consumption of Primary Energy in Power Plants of the MVM Group

	1985		1995	
	GWh	%	GWh	%
Brown coal	4,402	17.0	3,633	10.9
Lignite	3,786	14.7	4,157	12.5
Black coal derivatives	713	2.8	825	2.5
Coal sub-total	8,901	34.5	8,615	25.9
Fuel oil	4,504	17.4	5,477	16.5
Natural gas	5,781	22.4	4,917	14.8
Sub-total	10,285	39.8	10,394	31.3
Fossil fuel total	19,186	74.3	19,009	57.2
Hydraulic	155	0.6	164	0.5
Nuclear	6,480	25.1	14,026	42.3
Total	25,821	100	33,199	100

Source: MVM Statistical Data 1995, June 1996.

In 1995, nuclear energy accounts for 42.3 % of the total primary energy consumed in the MVM group power plants, followed by coals at 25.9 %, fuel oil at 16.5 %, and natural gas at 14.8 %. Brown coal and lignite, which are produced in Hungary, will remain as important fuels for power generation.

2.3 Electric Power Facilities

Figure 2.3.1 shows an outline of electric power facilities in Hungary.

Table 2.3.1 shows the power generation capacity in the country since 1985. The total commissioned generation capacity in 1995 was 7,403 MW, mostly of the MVM group power plants shown in Table 2.3.2. The capacity shares by power sources are 73.7 % by thermal power, 25.7 % by nuclear power, and 0.6 % by hydraulic power.

The power transmission system within the country consists of 400 kV, 220 kV and 120 kV lines. The 750 kV line is used for interconnection with Ukraine. Figure 2.3.2 shows the national power transmission lines and major distribution networks. The power distribution is undertaken by the six power distribution companies in the respective regions.

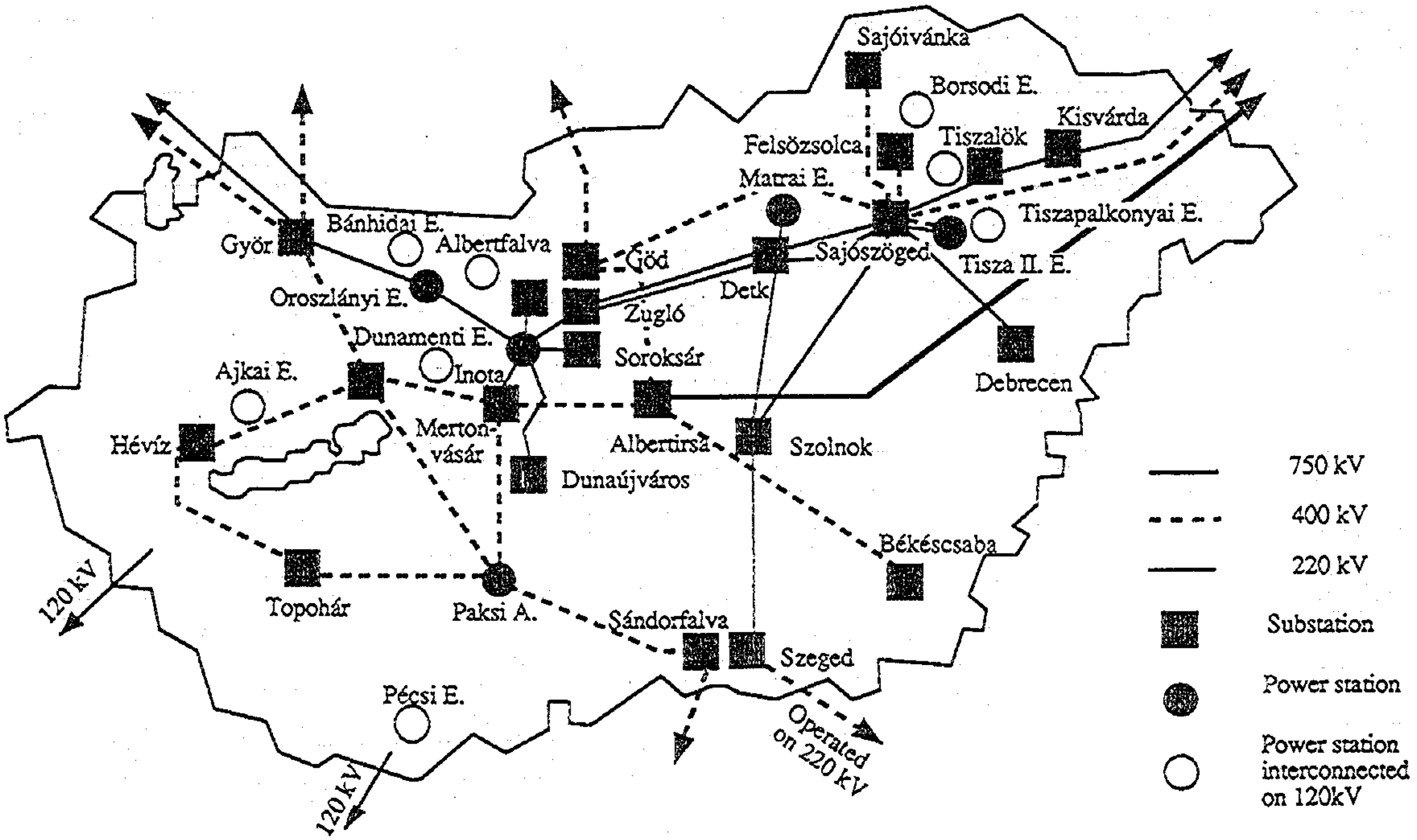


Figure 2.3.1 Basic Network System and Power Stations

Table 2.3.1 Power Generation Capacity in Hungary

Year	Commissioned Capacity (MW)	Available Capacity (MW)
1985	6,220	5,922
1986	6,680	6,368
1987	6,924	6,704
1988	7,172	6,907
1989	7,168	6,784
1990	7,184	6,812
1991	7,193	6,704
1992	7,278	6,662
1993	7,404	6,566
1994	7,317	6,676
1995	7,403	6,832

Source: MVM Statistical Data 1995, June 1996.

Table 2.3.2 Existing Power Stations of the MVM Group

		Units, turbines			In the year of 1995		
Power station	Fuel	Number	Capacity of each, MW	Tatal electricity capacity, MW	Nominal heat Capacity,* MW	Electricity generation, GWh	Heat supply, TJ
1. Ajka	coal	6	3×30+12+10+19	132	157.8	572	3,073
2. Borsod	coal	9	4×30+4+4.5+10+12+21	171	159.9	463	2,700
3. Budapest	hydrocarbon	16	min. 1.3−max.32	294	1,243.0	696	14,886
4. Dunamenti	hydrocarbon	12	6×215+3×150+40+2×20	1,820	456.0	5,025	2,423
4. Dunamenti GT	hydrocarbon	1	145	145		1,082	5,887
5. Mátrai	lignite	5	3×200+2×100	800	22.5	4,328	178
6. Inota	coal	4	2×20+12	72	38.1	100	500
6. Inota GT	oil	2	2×85	170	—	1	—
7. Oroszlány	coal	4	1×55+3×60	235	27.0	1,479	347
8. Paks	nuclear	8	8×230	1,840	29.0	14,026	605
9. Pécs	coal	5	2×60+2×35+30	220	300.0	917	2,942
10. Bánhida	coal	1	100	100	7.5	479	105
11. Tiszapalkonya	coal	7	1×50+13+15+7+3×55	250	149.4	656	1,574
12. Tisza II.	hydrocarbon	4	4×215	860	—	2,997	—
13. Kisköre	hydro	4	4×7	28	—	85	—
14. Tiszalök	hydro	3	3×3.8	11.4	—	43	—

* Available maximum.

Source: Ibid.

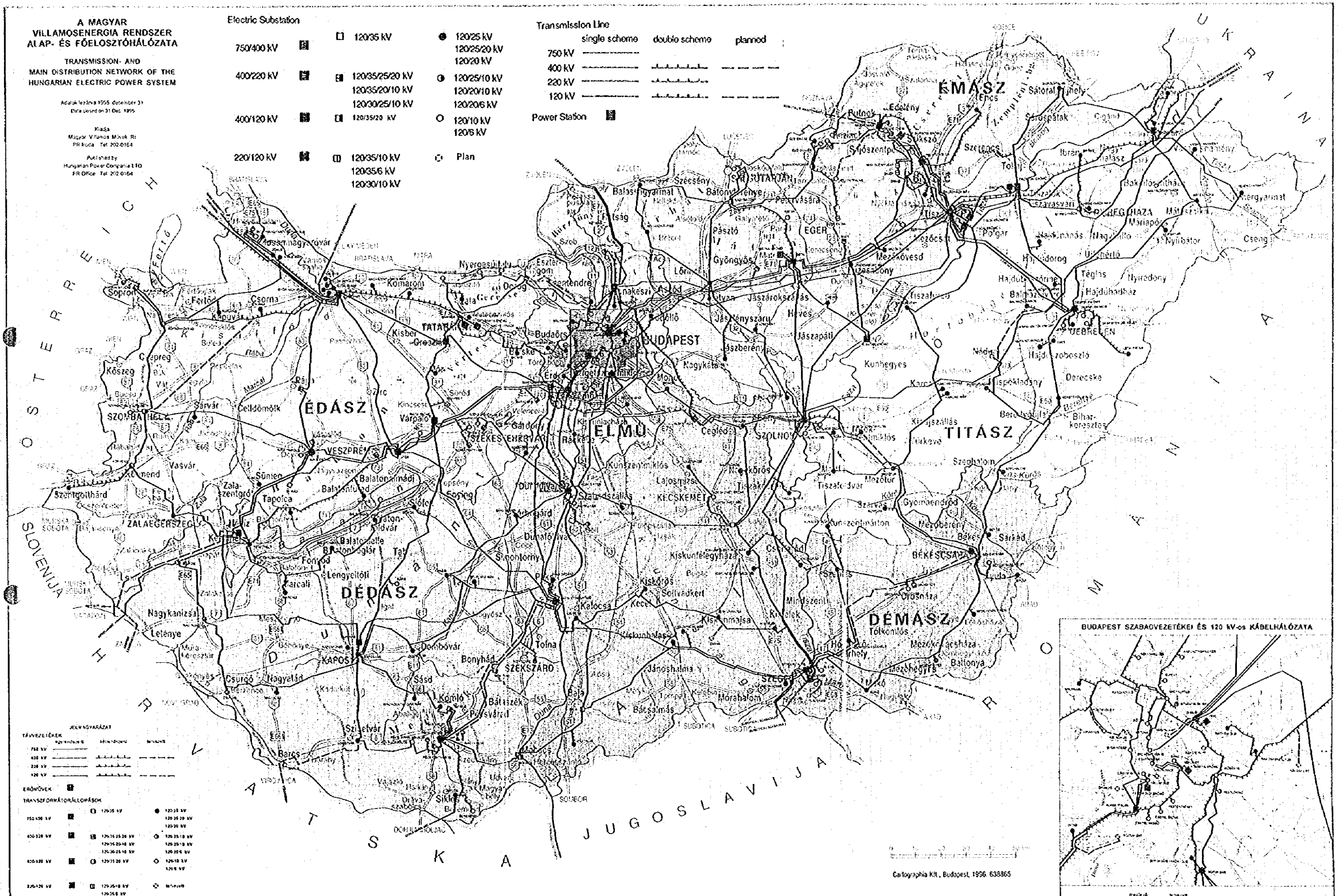


Figure 2.3.2 Power Transmission Lines and Major Distribution Networks

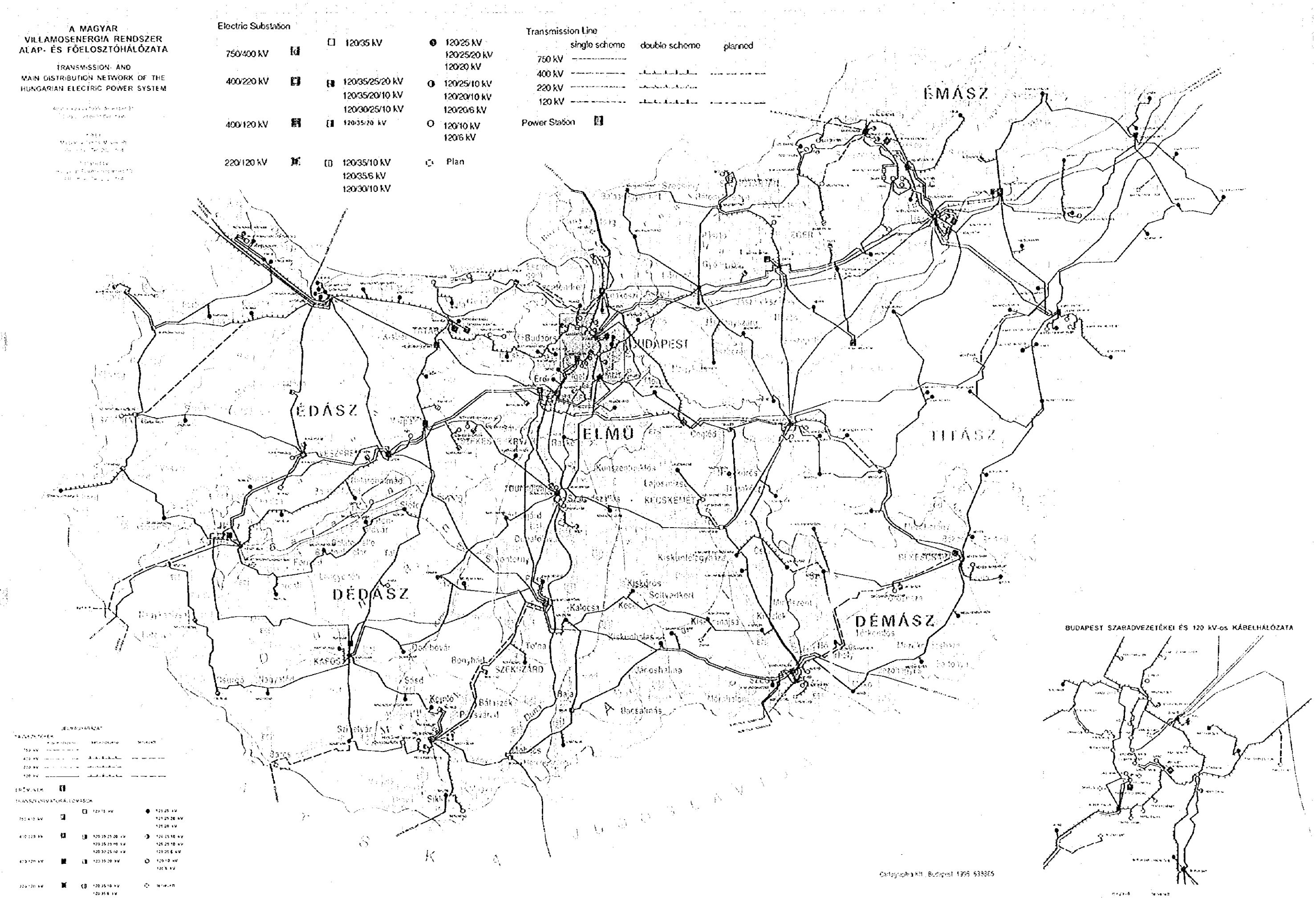


Figure 2.3.2 Power Transmission Lines and Major Distribution Networks

2.4 Projection of Electric Power Demand

The sudden collapse of the socialism market in the early 1990s brought about a sever economic recession, and Hungary is currently in the vortex of economic restructuring. Although the Government recognizes difficulties in projecting precisely the future energy demand under such situation, it forecast annual economic growth of 1 - 3 % for a long term accompanied by a substantial increase of energy demand. The total energy consumption was projected to increase from 1.063 PJ in 1995 to somewhere between 1,150 - 1,330 PJ in 2010.

The electric power consumption and the required power generation capacity projected by the Ministry of trade, Industry and Tourism (IKIM) are shown in Table 2.4.1.

Table 2.4.1 Electric Power Demand Forecast by IKIM

	1995	2000	2005	2010
Electric power consumption (TWh)	36.5	37.0 - 40.0	40.0 - 44.4	43.3 - 49.3
Nominal capacity (MW)	7,536	8,130	8,630	9,100
Real capacity (MW)	7,400	7,830	8,330	8,800

Source: IKIM, January 1997.

Figure 2.4.1 shows the projected power consumption together with the actual consumption figures in the past.

As shown in Table 2.4.1 and Figure 2.4.1, the future electricity demand varies considerably depending on the economic growth rate. However, the electricity demand is expected to increase steadily even in with the most pessimistic scenario. Since import dependence of electricity is not of national interest, and many of existing power plants will not be able to operate for another 10 years without substantial modification because of the environmental protection requirements, construction of new units and modernization of existing units are utterly needed.

Since new installation or scale-up of nuclear power plants will face considerable social difficulties, electricity demands have to be met largely by thermal power plants. The reconstruction project of Borsod Power Plant, in which domestic coal is used at maximum while introducing power generation facilities that satisfy environmental protection requirements, is considered to be of great importance in view of national interest.

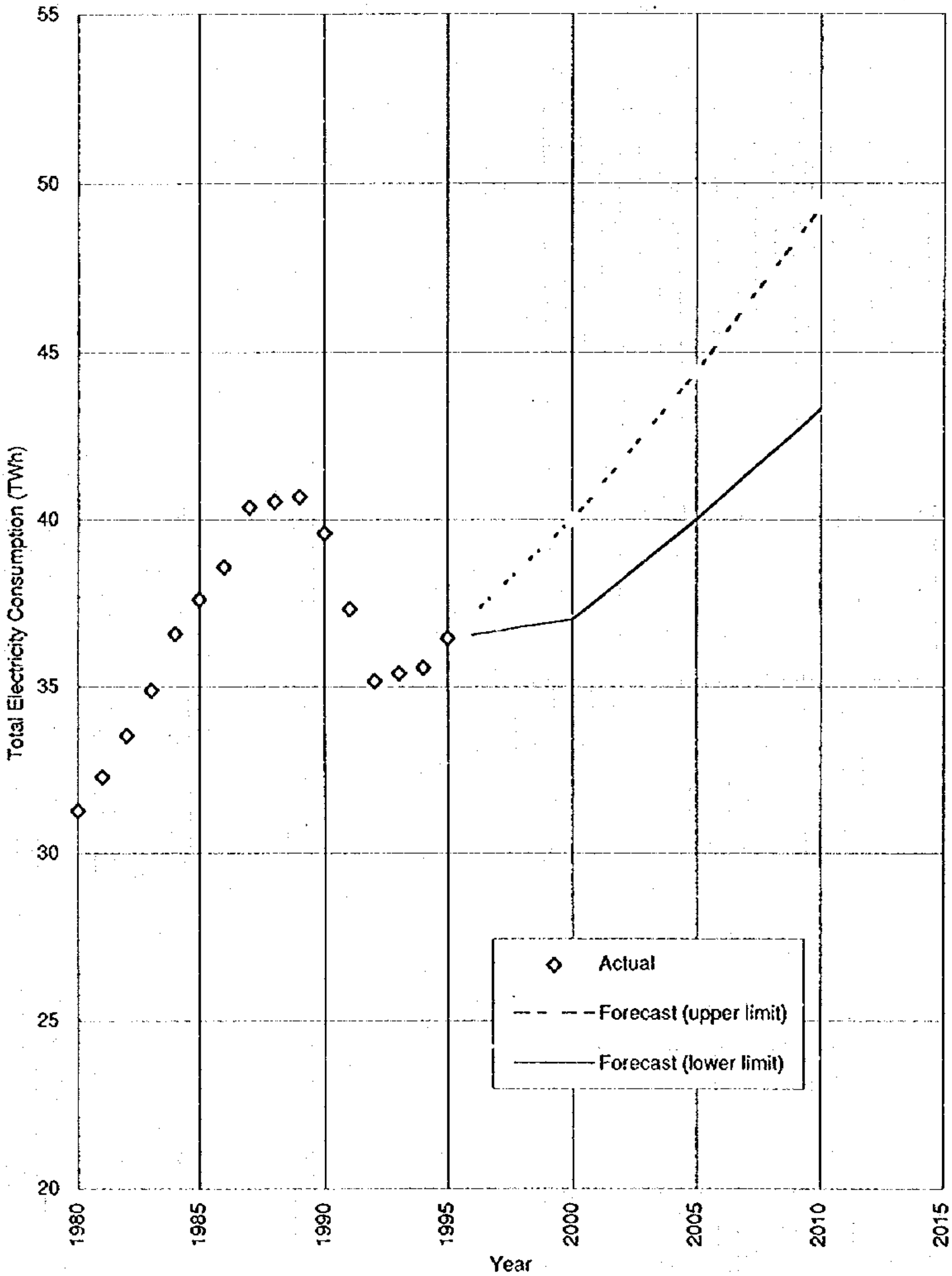


Figure 2.4.1 Electric Power Demand Forecast by IKIM

2.5 Outlines of Borsod Power Plant and Existing Development Plan

2.5.1 Outline of the Power Plant

Borsod Power Plant was established in 1957 on the basis of using local brown coal. Its original aim was basically the electric power generation. Later on, after Borsod Chemical Plant (BCP) came into operation, the plant took part in supplying steam to BCP and supplying hot water to the district heating system in the nearby area of Kazincbarcika.

As above-mentioned heat demands increased, more and more of the heat capacity originally designated to the electricity generation with condensing operation was spared for supply of steam and hot water. As the condensing capacity decreased significantly and the plant became unable to satisfy stringent new emission standards to be enforced, a rehabilitation program was planned, which consists of: a) construction of a new unit for power generation, and b) improvement of part of the existing facilities for supply of heat as steam and hot water for industrial and domestic uses.

(1) Boilers

There are 10 boilers of 100 t/h capacity in the closed boiler house of the power plant. They are manufactured by MHD and equipped with all necessary auxiliaries. Their major specifications are shown in Table 2.5.1

Eight (8) of these boilers are of Borsod-100-M type, and the other two (2) are of Borsod-100-R type. They are pulverized coal fired steam generators with supplementary gas and oil firing facilities.

Table 2.5.1 Major Specifications of Existing Boilers

Nominal output	t/h	100
Steam temperature	°C	500
Operational drum pressure	bar	79.4
Steam pressure at outlet	bar	74.5
Licensed pressure	bar	82.32
Max. output	t/h	110
Range of load (automatic)	%	50 ~ 100
Feedwater temperature	°C	190
Type of oil	-	TI 5/20
Heating value	kJ/m³	33,937

The boilers were reconstructed in four cycles during the period of 1978 - 1988 as shown in Table 2.5.2. In the recent years, boilers Nos. 5, 6, 7, and 8 were taken out of operation, and the adequate maintenance works have not been made on these units.

Table 2.5.2 Operational State of Existing Boilers

Boiler No.	1	2	3	4	5	6	7	8	9	10
Year of construction	1955	1955	1955	1955	1955	1956	1956	1956	1957	1957
Year of reconstruction	1982	1981	1980	1978	1979	1980	1983	1984	1988	1986
Present state	Operation				Standby				Operation	

(2) Turbines

Presently 9 units of steam turbines are installed. Their major specifications are shown in Table 2.5.3, and their overhaul years are shown in Table 2.5.4

Table 2.5.3 Specifications of Existing Turbines

No.	Supplier	Type	Output	Steam consumption
I ~ IV	LANG BBC	Condensing	32 MW	130 t/h
V	LANG Works	Condensing/ heating	25 MW	112 t/h
VI	LANG Works	Extraction, Back pressure	12.5 MW	200 t/h
VII	LANG Works	Extraction, Back pressure	5.3 MW	90 t/h
VIII	LANG Works	Extraction, condensing	6 MW	30 t/h
X	LANG Works	Extraction, back pressure	10 MW	90 t/h

Table 2.5.4 State of Existing Turbine Generators

Turbine No.	I	II	III	IV	V	VI	VII	VIII	X
Year of construction	1955	1955	1955	1956	1980	1978	1957	1960	1968
Year of major overhaul	1993	1994	1990	1991	1994	1990	1994	1987	1988

2.5.2 Existing Development Plan

The feasibility study by MVM/EGI on the reconstruction of Borsod Power Plant was completed in December 1993. The whole content of the study is presented in the following report and the attached volumes.

" Tisza Power Plant, Ltd., Borsod Power Plant, 150 MWe Unit, Detailed Feasibility Study," December 1993, EGI Rt., Client: MVM Rt.

The purposes of the reconstruction project are as follows:

1) To increase the power generation capacity to meet the demand from the national power system

2) To fulfill the responsibility of the long-term supply of heat to the region

For above purposes, the following new installation and improvements will be made:

1) A new unit of a capacity at 150 MW is constructed within the site of the plant to be used primarily for power generation.

2) The boilers and turbines in relatively good conditions among existing ones are modernized and repaired to be used primarily for heat supply.

The largest component of the new unit is a 460 t/h CFBC boiler in which domestic brown coal and imported hard coal are planned to be used in mixture.

Major specifications of the main facilities for the new unit are shown in Table 2.5.5.

Table 2.5.5 Major Specifications of the Facilities for the New Unit

Facility	Major Specifications				Remarks
Boiler	Evaporation rate	:	460/430	t/h	Reheat type CFBC
	Steam pressure	:	165/45	bar	
	Steam temperature	:	540/540	℃	
Turbine	Rating output	:	150	MW	Extraction, reheat, condensing type
	Steam temperature	:	535/535	℃	Casing: 3 (high/intermediate/low)
	Steam pressure	:	160/43	bar	Extraction stage : 7 stages
Generator	Terminal output	:	150	MWe	
	Revolution	:	3,000	rpm	

Note: One unit of 400 kW diesel generator will be also installed for emergency power supply.

In order to meet the contracted heat demand (241 MW) even when the new 150 MW unit is fully operated for electricity generation, 4 boilers (Nos. 5, 7, 9, and 10) out of 10 existing boilers shown in Table 2.5.2 will be reconstructed while satisfying the new emission standards. The other boilers will be abolished or in standby until the year 2001.

Regarding turbine generators, 4 existing units (Nos. 5, 6, 7, and 10) out of those shown in Table 2.5.4 will be used after appropriate repairing works. The others will be in standby or abolished.

Chapter 3

Study on Optimal Development Program for Borsod Power Plant

Chapter 3 Study on Optimal Development Program for Borsod Power Plant

3.1 Power Generation Capacity and Heat Supply Capacity

3.1.1 Power Generation Capacity of the New Unit

As described in Chapter 2, the situations concerning power development in Hungary are as follows:

1) The national electric power demand is expected to increase steadily towards future.

2) Most of existing thermal power generation units are quite aged with decreased power generation efficiency. Since they are not able to meet the stringent emission standards to be effected in 2005, they have to be shut-down unless substantial reconstruction works are made.

3) Accordingly, reconstruction of these existing power plants is urgently needed.

4) As a result of the privatization policy of the Government, coal mines near power plants were integrated into the management of power plant companies. Such power plant companies need to utilize their own coal as much as possible.

Under such situations, the Government established the national power plant development policy, which intends construction of gas-fired power plants in the majority of cases, and also construction of several 150 MW-class power units utilizing local coal. These 150 MW units are expected to serve as broad-load power units capable of wide-range output control.

The MVM's plan for construction of a new 150 MW unit in Borsod Power Plant is in line with such government policy. Its feasibility study (F/S) was conducted by a consultant (EGI) and completed in 1993, and this plan was basically approved by the Government.

The scope of work of the present Study, for the part of the new unit, is to review EGI's F/S and to make necessary modifications. Based on the above-stated circumstances, the capacity of the new unit is determined to be 150 MW. However, since the Plant may enlarge its total capacity in the future to meet further electricity demands from local consumers or the national power system, considerations will be given to such possibility in determining the layout of the new unit.

3.1.2 Heat Supply Capacity

Borsod Power Plant is supplying steam and hot water to nearby factories and a residence park. Since some factories are studying self-supply of electricity and heat, a precise projection of the future heat demand is rather difficult.

Table 3.1.1 shows the actual amount of heat energy supplied during 1994 - 1996 and the planned amount for 1997.

Table 3.1.1 Actual and Planned Amount of Heat Supply

(Unit : TJ)

Form of Heat		1994	1995	1996	1997 (Plan)
Steam	29 bar	1,980	1,831	1,798	1,805
	15 bar	44	52	89	116
	9 bar	123	155	220	225
	Sub-total	2,148	2,038	2,107	2,145
Hot Water		623	615	634	599
Heat Total		2,771	2,653	2,741	2,744

Source : Borsod Power Plant, January 1997.

During the four year period of 1994 - 1996, the amount of heat supply was minimum in 1995 at 2,653 TJ and maximum in 1994 at 2,771 TJ; quite stable trend.

In the F/S of EGI in 1993, the heat supply capacity of existing facilities to be renovated was studied based on the expected heat demand of 1993 shown in Table 3.1.2.

Table 3.1.2 Heat Demand for Planning

Peak Demand (MW)		Heat Delivery (TJ)		
		Winter	Summer	Total
29 bar steam	120	1,211	379	1,590
15 bar steam	9	124	16	140
6 bar steam	34	342	108	450
Steam sub-total	163	1,677	503	2,180
Hot water	78	515	85	600
Heat total	241	2,192	588	2,780

Since the figures in Table 3.1.2 are very close to the recent figures in Table 3.1.1, formulation of a program for renovation of existing facilities will be done by assuming the heat supply capacity at 241 MW, and the annual heat demand at 2,780 TJ.

3.2 Selection of Boiler Type for the New Unit

3.2.1 Conditions for Selection of Boiler Type

(1) Basic Considerations

1) Background

The Hungarian power system uses three different types of power plants designated as follows:

i) Base load power plant: 6,000~7,000 h/a
ii) Broad load power plant: 3,000~5,000h/a
iii) Peak load power plant: max.1,000 h/a (evening peak load)

At present, the power system covers the changes in demand by using hydrocarbon-fired blocks of 200 MW capacity. These power plant units suitable to be controlled within a wide range can be loaded and released within a short time. However, large variations in the load wear down the equipment. The need for maintenance is increased and their service life is significantly reduced.

In order to overcome the process and problem outlined above as well as taking the domestic primary energy sources available into consideration, a strategy was developed, which specified that flexible condensation blocks of up to 150 MW unit capacity, fired with Hungarian coal, will be needed in the years following the millennium.

First, the use of fluidized bed hybrid fired boilers was considered. With the environmental regulations relating to the emission limit values finalized, it became evident that this type of boilers is unable to fulfill these requirements.

The pulverized coal fired boilers provided with flue gas desulphurizer are capable of fulfilling the requirements relating to the limit values. Nevertheless, in respect of the desulphurizer, it is difficult and, in addition, uneconomic to follow the nearly continuous changes in the boiler load.

It is for this reason that the circulation type fluid bed fired boiler was selected; in fact, this type of boiler is capable of fulfilling the emission requirements even without a desulphurizer.

2) Considerations for selection of boiler type

The following points were taken into consideration for the selection of the boiler type for the new unit.

i) Borsod brown coal is used as a main fuel.
ii) Emission standards to be applied in 2005 need to be satisfied.
iii) Least construction cost with existing technology
iv) Utilization of the existing F/S report to the maximum extent

(2) Functional Conditions for New Unit

1) Duty of new unit

Duty of new unit is as follows:

i) New unit will supply power to the national power system.
ii) New unit will supply heat to the surrounding area.

2) Electric output and heat production

Electric output and heat production of new unit are as follows:

i) Electric output: 150MW x 1 unit
ii) Heat production: 130MW

3) Design coal and limestone

Coal and limestone of new unit is as follows:

i) Borsod coal + import coal mixture (50:50% mixed on calorific value base): Table3.5.7

ii) Natural gas: Table 3.5.9

iii) Fuel oil: Table 3.5.10

iv) Limestone: Table3.6.1

4) Yearly plant availability

Yearly availability of new unit is 6,000 hours, taking the operational outage into consideration.

i) Theoretically maximamu: 200 h/a
ii) Base load: 6,000 h/a
iii) Broad load: 4,000~5,000 h/a

5) Emission standards for the new unit

Emission standards of solid fuel coming into effect in 2005 are shown in Table 3.2.1. Emission standard of SO_2 can be calculated according to the following equation.

$$2{,}400 - 4 \times Pth \quad \text{----} \quad Pth = 382\ MW$$

Table3.2.1 Planned Emission Standard (2005)

Pollutant	Solid fuel (mg/Nm^3)
Soot & dust	50
CO	25
NOx as NO2	400
SO2(382MWth)	872
HCl	100
HF	15

Note: These values are converted to the normal condition of oxygen concentration of 3 % in exhaust gas.

3.2.2 Selection of Boiler Type

The studies were made on two types of boiler system: CFB boiler, as selected in the past F/S, and pulverized coal firing (PCF) boiler plus flue gas desuefurization (FGD). Various types of technology for combustion facility from the viewpoint of environmental protection are shown in Chapter 6.

(1) CFB Boiler

1) State of large-scale CFB boiler technology

Most of CFB boilers currently in use are of middle-to-small capacities and use bituminous coal with a high calorific value. In case of a large-scale boiler such as that considered in Borsod Power Plant, it is still a developing technology. No large-scale boiler firing coal of low calorific value and high ash content like Lyuko coal exists. The Study Team investigated large-scale CFB boilers with the evaporation capacity of 350 t/h or more and fuels used in them.

The following three power plants have a CFB boiler of a evaporation capacity of 350 t/h or more, firing low calorific lignite or brown coal:

i) Texas-New Mexico Power Station, TNP-One (USA)
ii) Provence Power Plant (France)
iii) Goldenberg Power Station (Germany)

As the results of the study of the CFB boilers in above 3 power plants, many operational problems were found, especially in the case of TNP-One. Erosion and crack of nozzle by bed ash and bed ash removal system including ash cooler were major problems. As the amount of ash discharged increases, it was found that the problem was more serious. On the other hand, in case of Provence Power Plant, the problems caused by ash was less because 57 % of ash content in the fuel is CaO (For detail see Supporting Report). The features of the CFB boilers in the three power plants are shown in Table 3.2.2.

Table 3.2.2 Features of Large-scale CFB Boilers in Three Power Plant

Site of installation	TNP-One (USA)	Provence PP (France)	Goldenberg PP (Germany)
Manufacturer	Combustion Engineering	Stein Industries	EVT Steinmüller
Steam generation	499 t/h	700 t/h	400 t/h
Fuel	Lignite/natural gas	Lignite/oil	Rhine brown coal
Year of commissioning	1990	1995	1992
Fuel characteristics Net heating value Ash content Moisture Sulfur content	 15.5 MJ/kg 15.5% 30.0 % 1.0 %	 13 MJ/kg 28 to 32 % (CaO 57%) 11 to 14 % 3.7 %	 9 MJ/kg 7.0 % 53.2 % 0.5 %
Combustion chamber	125.5 x 11 x 46 m	data not available	data not available
Limestone supply	yes	unnecessary	yes
Cyclones	4 pcs, 6.4 (dia.) x 22.5 m	data not available	4 pcs
External heat exchanger (EHE)	yes (2)	yes	none
Dust collection	Bag type filter	EP	EP
Ash handling	Mechanical, water cooled screw conveyor	Fluidized, with cooler	Fluidized, with cooler
Substitutation for CFB boiler	100% gas firing	heavy fuel oil firing	2 x145 t/h oil fired boiler for standby
Construction cost	USD 150 million	data not available	data not available

2) Substitution for failure of CFB boiler

Substitution for CFB boiler of each power plant are as follows:

i) TNP-One P.P. : Back up all capacity with natural gas.
ii) Provence P.P. : Back up all capacity with natural gas and heavy oil
iii) Goldenberg P.P. : Two oil-fired boilers of 145 t/h (70% of full load)

3) Measures for application of CFB boiler in Borsod Power Plant

In case CFB technology is applied in this project, the following measures should be taken considering that the main fuel is Borsod coal.

a) Appropriate loading on the separation and recycle system or EHE system of ash from the combustor

To reduce loading on separation and recycle system or external heat exchanger (EHE) system of ash from the combustor to a similar level of the CFB unit at the Provence Power Plant that has already been proven, the ash generation of the new CFB unit at the Borsod Power Plant should be reduced from 80 t/h to 44 t/h by mixing Lyuko brown coal and import coal at a ratio of 1:1 in calorific value.

b) Quality of import coal

Import coal to be mixed must be of high quality with 25 MJ/kg or higher calorific value and 0.8-1.0% of sulfur content.

c) Limestone feeder

Limestone feeder also has frequent failure. The findings from these problems of TNP-1 must be reflected on the new CFB unit at the Borsod Power Plant.

d) Heat load balance

Heating load of the superheating and reheating at the superheater, reheater, ash separator and recycle system or EHE system must be well-balanced.

e) Control of ash separator and recycle system or EHE system

Close connection and adjustment by minutes or seconds is carried out between ash separator and recycle system or EHE system, combustor and primary air fan. Use computers to monitor each process, receive any fed-back data, and provide close linkage.

(2) PCF Boiler Plus FGD

1) Outline of PCF+FGD

An alternative to the CFB boiler can be the PCF boiler that type has been in use in Hungary for decades, completed with EP and FGD. At present, a large number of pulverized coal fired boiler are in service in power plants worldwide. The largest brown coal fired unit is of 800 MW capacity.

FGD is divided into the type of dry, wet and semi-dry. The Study Team studied wet type FGD as the alternative because wet type makes up 70 % of worldwide installation and is evaluated as matured technology. Outline of PFC + FGD is shown in Figures 3.2.1 through 3.2.3.

2) Features of the Technology of Wet-type FGD

The limestone-gypsum method, a widely used method of wet-type FGD, has the following features:

- High desulfurization efficiency (>90%)
- Limestone used as desulfurization reagent may be found everywhere in large quantities and at low price.
- High utility and operational safety
- Utilizable by-products (gypsum)
- Large number of references, much operational experience
- Large space required
- Large quantity of water required
- High investment costs

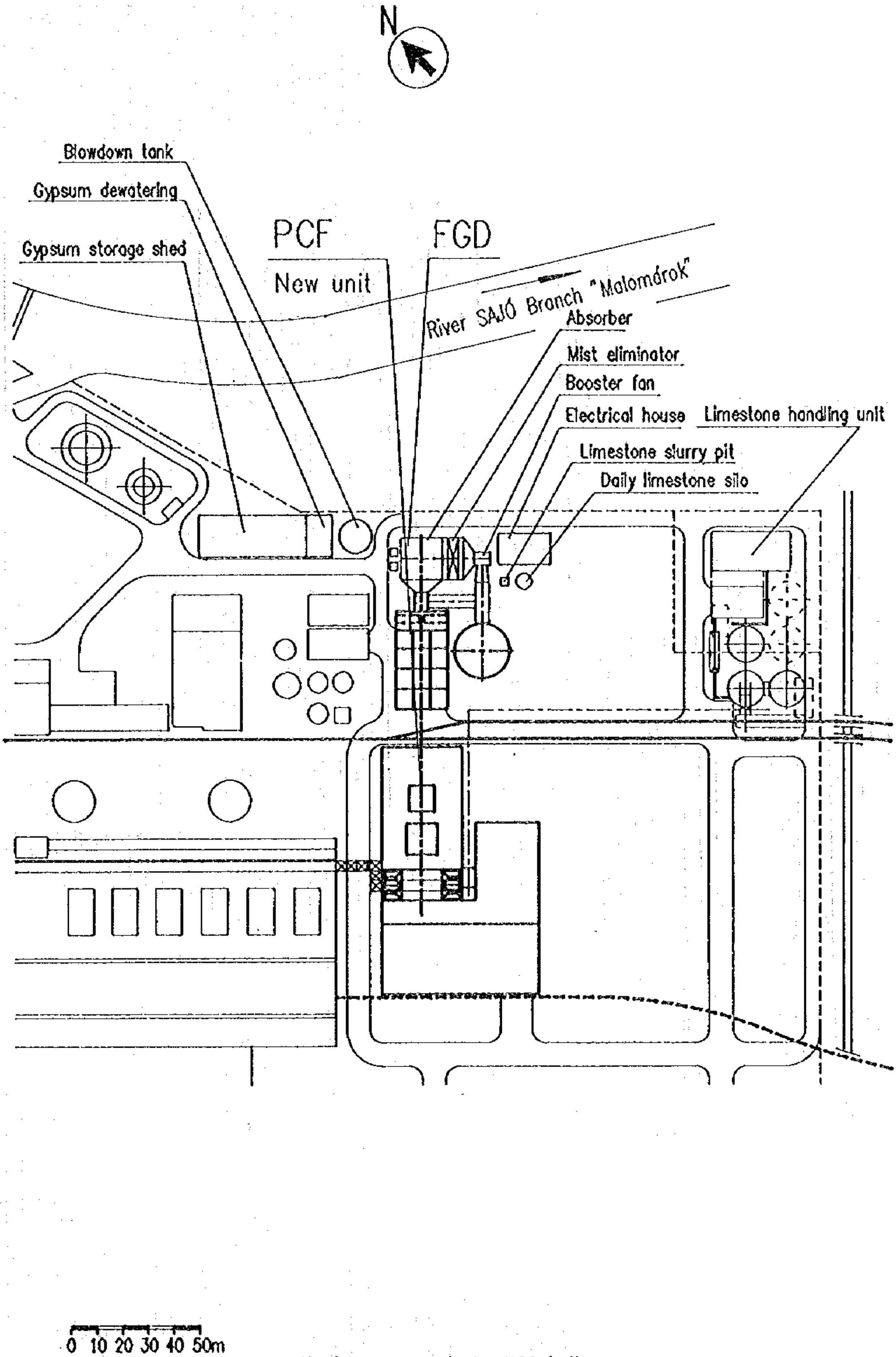


Figure 3.2.1 Layout of PCF+FGD boiler

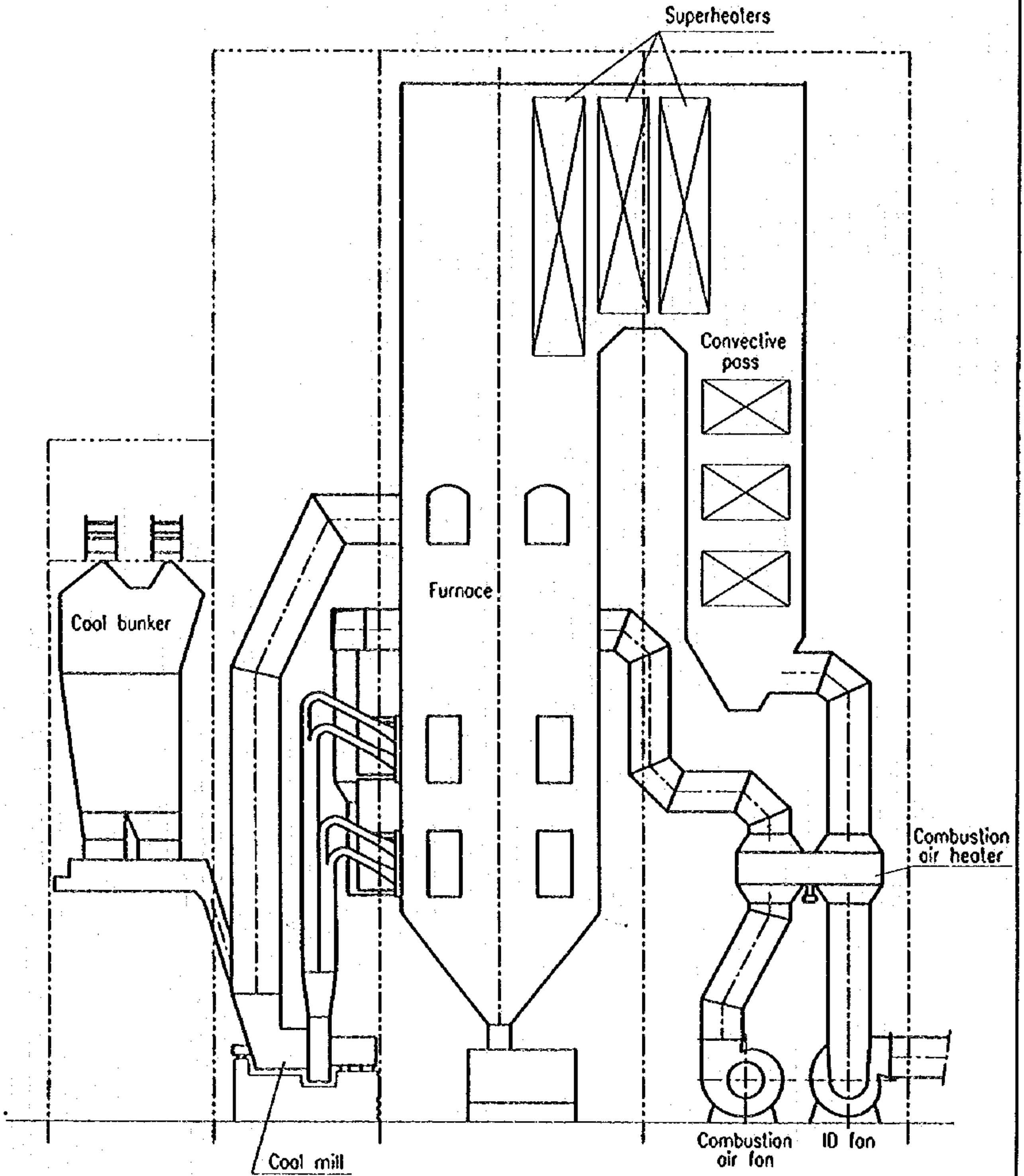


Figure 3.2.2 Side view of PCF boiler

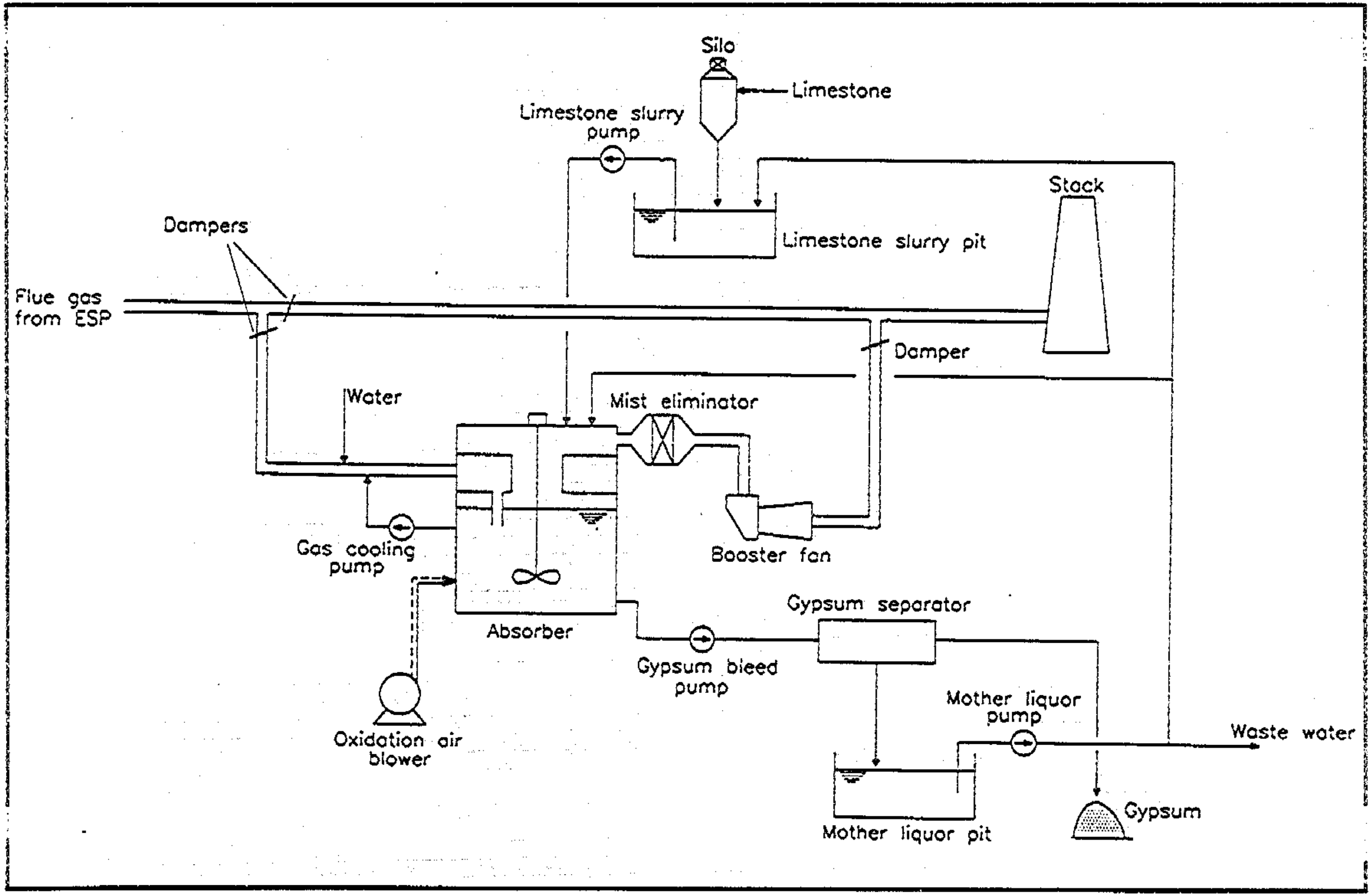


Figure 3.2.3 An example of FGD flow diagram

(3) Selection of Boiler Type

Comparisons of major aspects of two types of technology are summarized in Tables 3.2.3 and 3.2.4. Considering the conditions of Borsod Power Plant and comparing the initial cost and running cost for service life of CFB+EHE and PCF+FGD, the technology of CFB+EHE is judged to be more favorable. Therefore, it is selected.

Table 3.2.3 Comparison of CFB+EHE and PCF+FGD (1)

Characteristic	CFB+EHE	PCF+FGD
Principle of operation	Bed material consisting of a mixture of bed ash, coal, and limestone powder is in intensive motion under fluidized circumstances a cyclone feeds the bed ash back to the combustion chamber. Basically, the heat transfer takes place within the combustion chamber by means of convection. Desulfurization takes place within the combustion chamber	Coal will be ground into powder in mills and dried by using hot flue gas. The dried pulverized coal will be transported by means of the drying flue gas and blown into the combustion chamber where it burns at a high temperature.
Fuel Coal Size Surface moisture content	 Lignite, brown coal, hard coal, oil slate, wood chips etc. within very wide range of heating value 0.1 to 40 mm, depending on design. Low, in order to avoid any trouble in fuel supply	 Lignite, brow coal, hard coal. 0 to 10 mm, min 75% is below 200 mesh. Low, in order to avoid any trouble in fuel supply
Bed material	Bed ash, limestone grist, coal, sand	---------------
Desulfurizing reagent in the combustion chamber	Limestone powder, grain size between 0.1 and 3.0 mm	----------------
Performance - Combustion chamber temp. - Excess air - Combustion efficiency - Boiler efficiency - Desulfurization - Ratio of desulfurization - Calcium/sulfur ratio - Reduction in nitrogen oxide emission - Rate of load change - Minimum permanent load - Other features	 770 to 860 °C 1.2 to 1.3 99% 90.3 % by using limestone in the combustion chamber > 90% 2.0 to 3.0 Low combustion temperature with multi-stage air supply 3%/min. Less than 40% of MCR Low flue gas temperature at the boiler outlet Combustion chamber temperature easy to control No slag deposit in the combustion chamber Self consumption of el. energy: approx. 6 to 7%	 1300 to 1500 °C 1.2 to 1.3 99% 86 to 88 % wet limestone-gypsum procedure downstream the boiler >90% 1.05 to 1.1 Low NOx burners with multi-stage air supply 3%/ min. 40% of MCR Higher flue gas temperature at the boiler outlet. Good adaptability to variable fuel parameters. Combustion chamber susceptible to slag formation and dirt.
Different structural elements - Combustion chamber - Gas flow velocity - Staying time in comb. chamb. - Fuel supply - Coal processing - Others - Air supply	 Membrane wall, wear resistant wall on its lower part 5 to 15 m/s 3 to 5 sec Fluidized transport from bin, charging into the combustion chamber or the bed ash return line Traditional, grinding, homogenizing in the combustion chamber. Boiler capacity can be increased by the number of cyclones. Complicated, uses various fans and blowers	 Membrane wall - 1 to 5 sec The pulverized and dried coal will be transported by means of the drying gas to the pulverized coal burners. Grinding, sieving, mixing, transport into raw coal bunker. Various firing systems depending on the ash- and moisture content of fuel

Table 3.2.4 Comparison of CFB+EHE and PCF+FGD (2)

Characteristic	CFB+EHE	PCF+FGD
History - Date of development - Number of units already commissioned - Max. unit capacity already implemented - Future vision (for lignite)	 The eighties Several hundred, certain units exceed 400 tons/hour 250 MW 400 to 600 MW unit capacity, in development	 The sixties Several thousand, mostly at large power plants 600 MW (800 MW Boxberg, Scwarze Pumpe)
Technical level	Usual as for small and medium size units; several pilot pant of large unit capacity.	General use in power plants between 50 and 800 MW
Reliability	Erosion problems with cyclones, low part of combustion chamber, heat exchangers in fluid bed. No practical data for local brown coal are available.	Erosion, corrosion and scaling problems in FGD No experiences with flue gas desulfurization of coals with high sulfur content.
Operational features - Sensitivity to load changes - Operational safety - Cold starting time - Stability	 Good Good in continuous operation Long Good	 Good Good. Fall out and scaling problems may occur with FGD The shortest Good
Maintenance requirements	Mostly erosion problems	FGD shall be inspected for erosion and corrosion and the deposit in absorber and pipes shall be removed
By-products	Mixture of bed ash and flue ash (ash, limestone, gypsum etc.), depositing into slurry depot, tends to solidify.	Flyash and gypsum separated The gypsum produced can be utilized
Space requirement of installation	More favorable than pulverized coal firing with desulfurizing	Due to FGD, higher than in the case of CFB. It can be installed at the area available
Time requirement of installation	Usual, however, without knowledge of fuel, longer time of commissioning and adjustment shall be taken into account	Usual, however, due to the high sulfur content, the FGD may require longer commissioning time
Environmental problems	Meets the emission standard by 90 % of desulfurization ratio. End product of desulfurizing is unable to be utilized.	Meets the emission standard by 90 % of desulfurization ratio.
Level of technologic development	Adaptable Environmental measurements and adjustment are necessary for low quality coal	Adaptable The results of environmental measurements are acceptable; in respect of FGD of high power and high sulfur content, further experiences are needed
Economic problems - Investment costs - Specific costs of electric energy	 155,957,400 USD 5.79 cent/kWh	 171,270,950 USD 6.29 cent/kWh
Economic judgment	Good It is more economical as compared to PCF + FGD up to about 250 MW unit capacity.	Normal

3.3 Selection of Turbine and Generator Types for the New Unit

(1) Selection of Turbine Type

1) Steam turbine

To install a new turbine unit of 150 MW capacity in Borsod Power Plant, the tandem compound double flow (TCDF), reheat type turbine is selected for the following reasons:

(a) 210 MW turbine generator units of the TCDF type have been successfully operating for more than a decade at Tisza II Power Plant, and been maintained without any significant problem.

(b) TCDF type is the most familiar class layout of turbine generator unit in the world including Hungary. This is the most reliable type of design having much experience of operation.

In this class of turbine units, the two and three casings types are the most familiar design.

(a) Two casing type

The high and medium pressure section and the low pressure section form two casings.

(b) Three casing type

The high pressure, medium pressure, and low pressure sections are forming independently three casings.

In this project, the three casing type design is proposed by laying stress on the ease of maintenance and inspection, and the operational stability.

2) Bearing support of the turbo generator section

To support the turbo generator rotor at journal bearing, there are two design philosophy: (1) conventional two bearing support, and (2) one bearing support, reducing number of one generator bearing, for the common bearing at the LP turbine end.

In this project, considering erection work, centering, maintenance, and inspection, the orthodox two journal support design is adopted.

(2) Selection of Generator Type

The new turbo generator selected is designed as three phase synchro-generator with static excitation, of lateral positioned, cylindrical, rotating field, anti-explosion type structure. The reasons for this selection are as follows:

(a) In the many power stations in Hungary, as adopted in Tisza I & II, this type is wildly installed and well accustomed to operate and maintain.

(b) This is the most reliable type of design, and proven by long history of operation.

3.4 Plant Layout of the New Unit

3.4.1 General Considerations

In Borsod Power Plant, a new 150 MW unit will be installed and some of the existing facilities will be renovated. The following are important factors in this project for planning the plant layout:

(1) Basically, brown coal of Borsod and imported hard coal mixed in the ratio of 50-50% in respect of their heat equivalent are used as fuels for the new unit.

(2) The new 150 MW unit should be also capable of natural gas firing for the case of troubles in coal supply or fly ash removal.

(3) Existing four boilers will be reconstructed into those firing natural gas and fuel oil of low sulfur content.

The above factors require the following items to be examined for determining the plant layout:

(1) Selecting the location to establish the new 150 MW unit.

(2) Specifying the configuration of the new unit.

(3) Storage and handling of the imported coal.

(4) Expanding the hydrocarbon fuel supply. At present, supply capacity of 15,000 m^3/h (n.c.) for natural gas, and 200 m^3 storage capacity for oil is available.

(5) Establishing limestone handling system

(6) Installation of equipment for slag and fly ash removal for the 150 MW unit.

(7) Installation of high-, medium- and low pressure equipment for the new unit.

(8) Tasks relating to the upgrading of the fresh-water supply system.

(9) Installation of the cooling system for the 150 MW unit.

(10) Expanding the water treatment equipment and sewage treatment basin.

(11) Installation of the central control room, together with social facilities for the staff working with the new unit.

(12) Modifying the railway siding network and the road network of the Power Station in relation to the installation of new objects.

3.4.2 Determination of the Plant Layout

(1) Site Selection

For the location of the new unit, two sites " A" and " B" , as shown in Figure 3.4.1, were considered.

The selection of Site A requires to acquire an new area, as shown in the Figure, for the limestone plant.

However, the following severe disadvantages are associated with the selection of Site B:

1) The site is available only when the renovation of the existing facilities are completed and the site is cleared before the construction of the new unit.

2) Releasing the area necessitates large volume of demolition works (demolition of boilers No. 1 to No. 4, turbines No. I to No. IV, boiler building, bunker tract, stack No. 1, and the cooling tower out of service).

3) There is no possibility to install a second 150 MW unit close to the first one.

4) Prior to the start of demolition, significant amount of relocation and replacement works have to be done in order to ensure the operation in the remaining part of Power Plant.

As a result of comparing 2 sites, Site A has been selected for the location of the new unit.

(2) Selection of Basic Layout at Site A

As the basic layout of the new unit, two versions "T" and "I", that indicate the relative location of the boiler axle and the turbine shaft, can be considered. The direction of boiler axle in both schemes are determined by the railway siding track that serves the existing water treatment plant and oil tank farm. The limestone handling of the new unit also requires the track of north-west direction, together with the new track to be built in parallel to it.

The objects to be installed are the same in both the "T" and "I" schemes, namely:

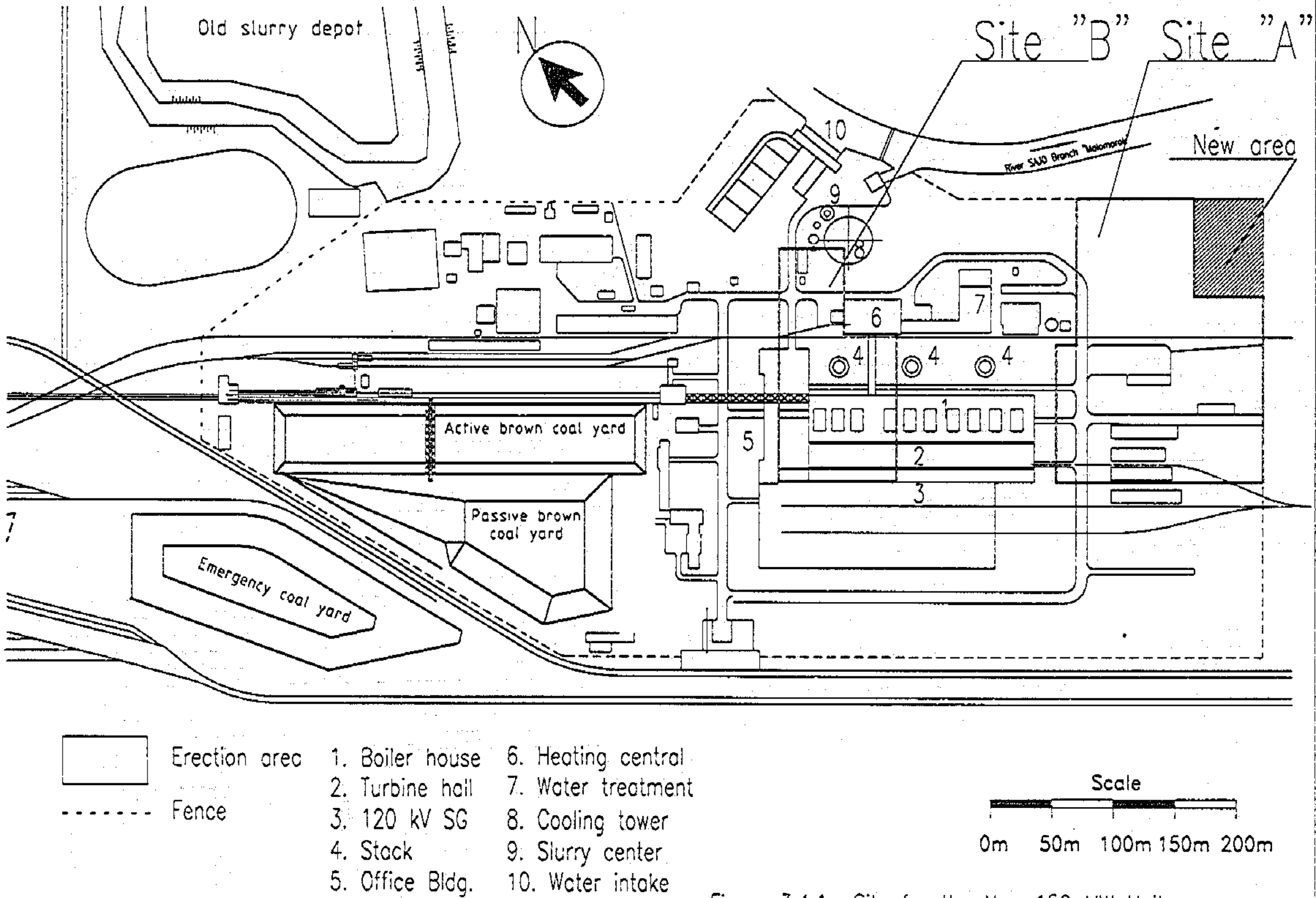


Figure 3.4.1 Site for the New 150 MW Unit

(a) Turbo-generator building and feedwater building
(b) CBF+EHE boiler of 460 t/h capacity
(c) Electric precipitator, induced draft fans and stack
(d) Multi-purpose building for electric equipment, control room and social facilities
(e) Wet cooling facility with pump building
(f) Electric power equipment (main transformer, auxiliary transformer, and starting transformaer)
(g) Limestone plant to be established in the vicinity of the new unit

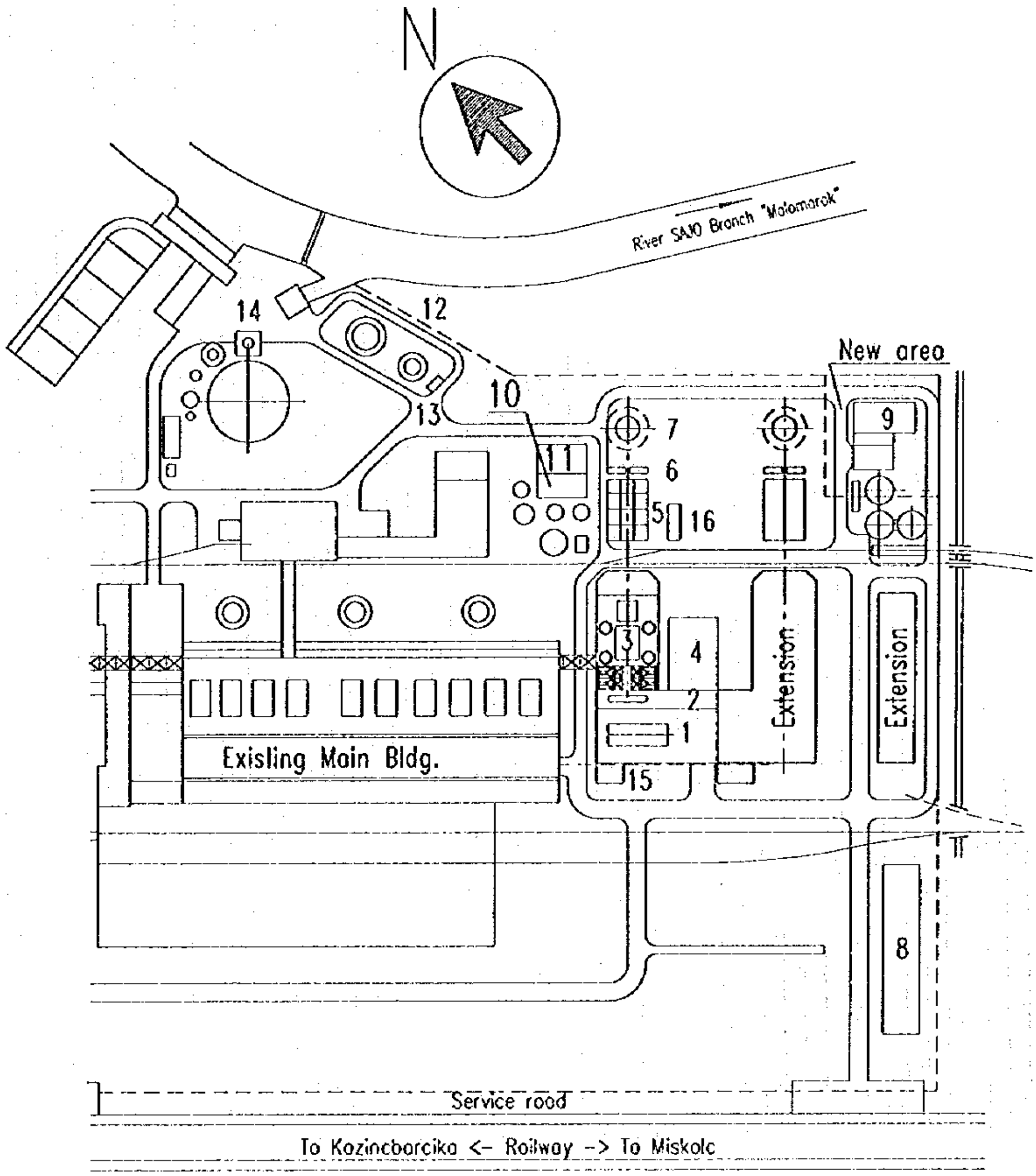
The layout of version " T" is shown in Figure 3.4.2, and that of " I" version is shown in Figure 3.4.3. Comparison of " T" and " I" layout versions is summarized in Table 3.4.1.

Table 3.4.1 Comparison of " T" and " I" Layout Versions

View Point	Layout T	Layout I
Footing area of machine hall	60 x 27 m = 1,620 m²	48 x 45 = 2,160 m²
Cost of establishing the machine hall	100 %	170 %
Bridge crane's span	appr. 25.5 m	appr. 43 m
Cost of installing the crane	100 %	appr. 300 %
Status of the assembly port in case of extension	To be established again	Remains unchanged
Railway sidings to be liquidated	Track VII to the old machine hall	Track VII and Track VIII to the switchyard
Tasks concerning the sidings in case of extension	None	Trace modification of track IX
Accessibility for extension	Acceptable	Good
Design of the high-pressure steam line between boiler and turbine	Acceptable	Excellent
Trace design of the sheathed bus-bars between generator and main transformer	Acceptable	Economical and good

From Table 3.4.1, the version T is considered to be more advantageous, primarily due to the smaller area and volume of the machine hall (turbine building) as well as the costs of the crane of smaller span.

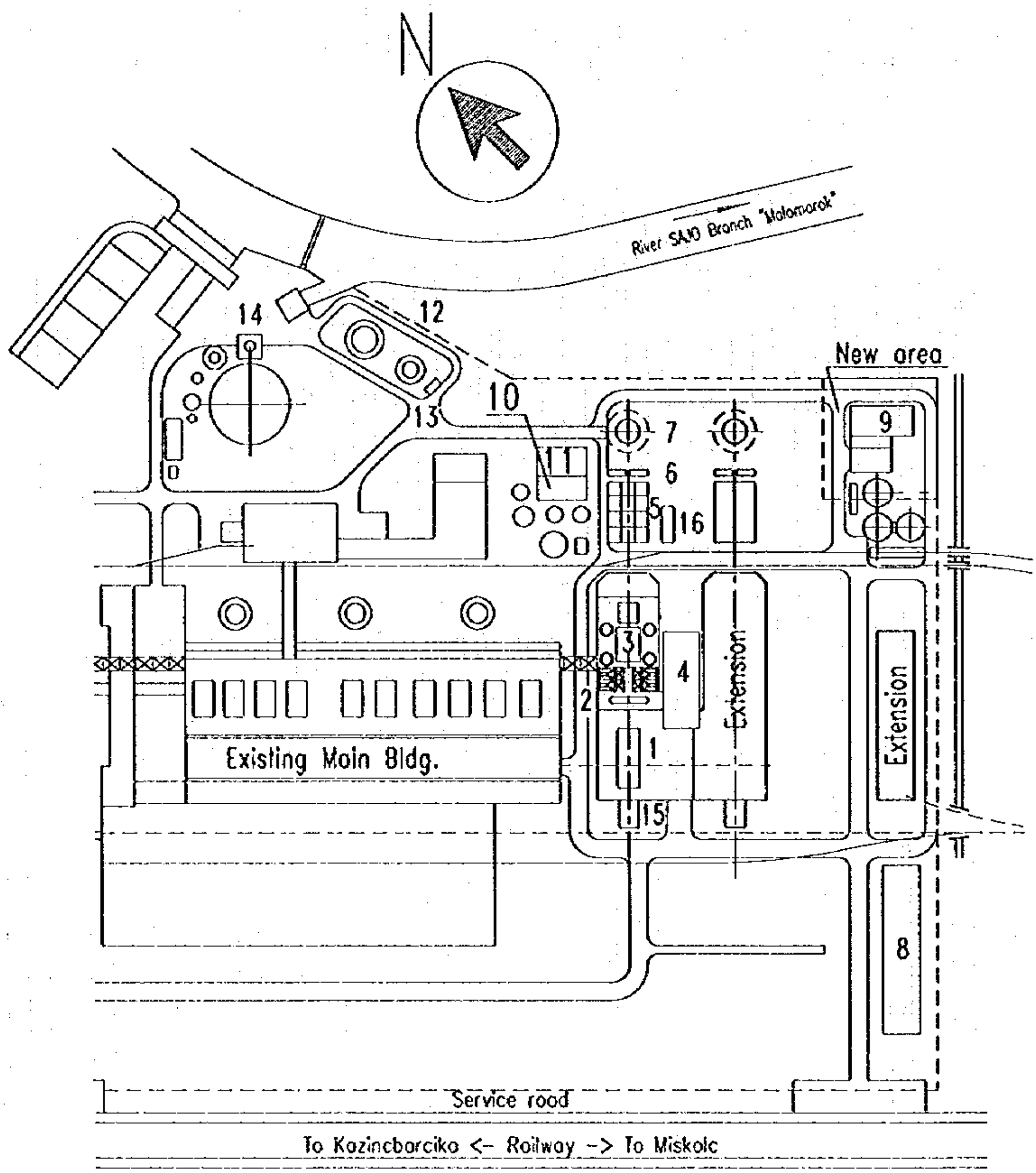
Therefore, the T layout shown in Figure 3.4.2 is chosen for the new unit.



1 Turbine hall
2 F.W house
3 CFB + EHE Boiler
4 Electrical & Control Bldg.
5 Electrostatic Precipitator
6 I.D. Fans
7 Stack
8 Cooling Tower
9 Limestone plant
10 Water treatment plant
11 Waste water basin
12 Oil storage
13 Oil pump house
14 Slurry center
15 Transformers
16 Air station

Figure 3.4.2 Power Plant Layout of Version "I"

Scale
0m 25m 50m 75m 100m



1 Turbine hall
2 F.W house
3 CFB + EHE Boiler
4 Electrical & Control Bldg.
5 Electrostatic Precipitator
6 I.D. Fans
7 Stack
8 Cooling Tower
9 Limestone plant
10 Water treatment plant
11 Waste water basin
12 Oil storage
13 Oil pump house
14 Slurry center
15 Transformers
16 Air station

Figure 3.4.3 Power Plant Layout of Version "I"