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

Summary

August 1997

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

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

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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.

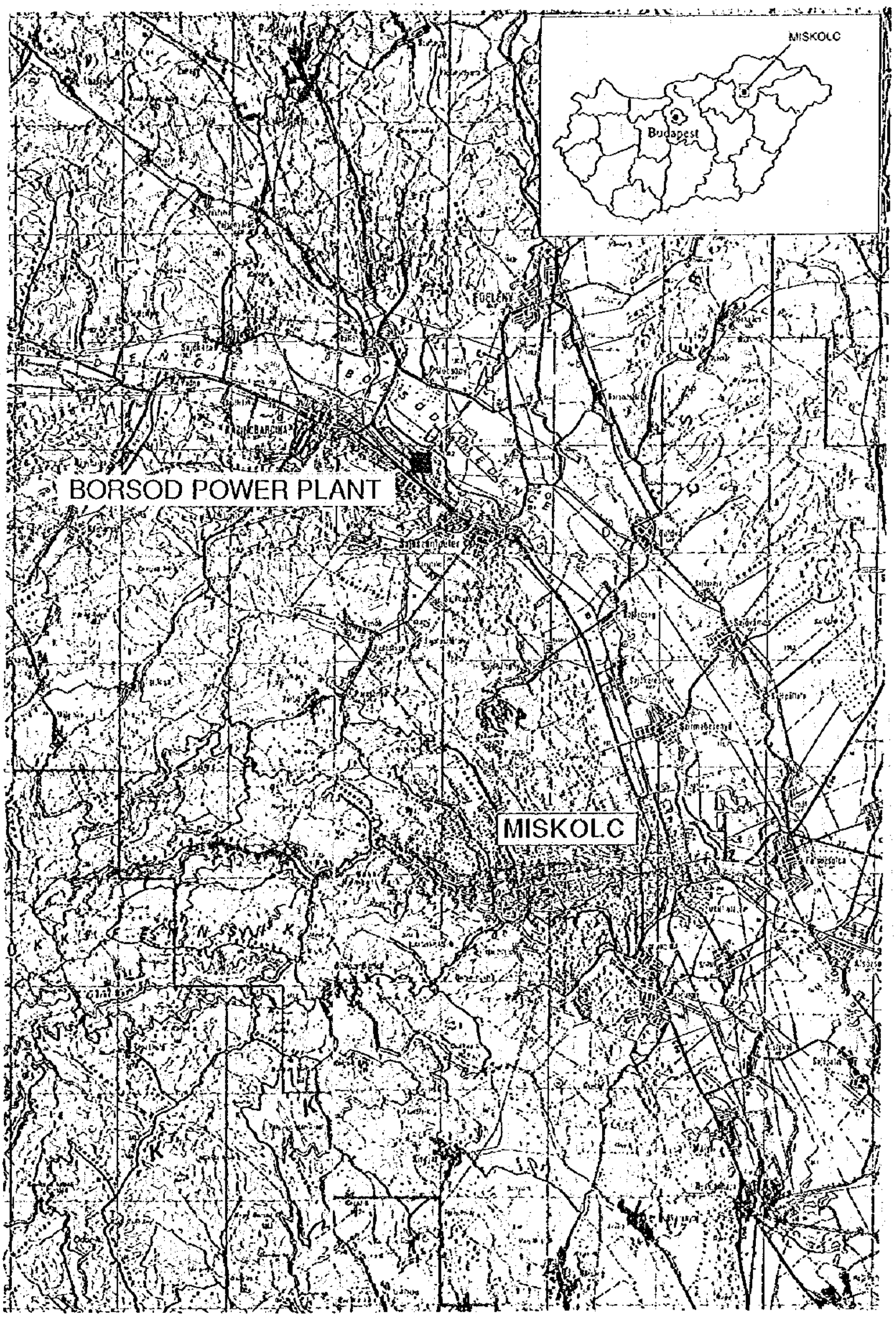
We wish to express grateful acknowledgments to your Agency, Ministry of Foreign Affairs, and Ministry of International Trade and Industry. We also wish to express our sincere appreciation to Hungarian agencies concerned including the Ministry of Industry, Trade and Tourism, Ministry for Environment and 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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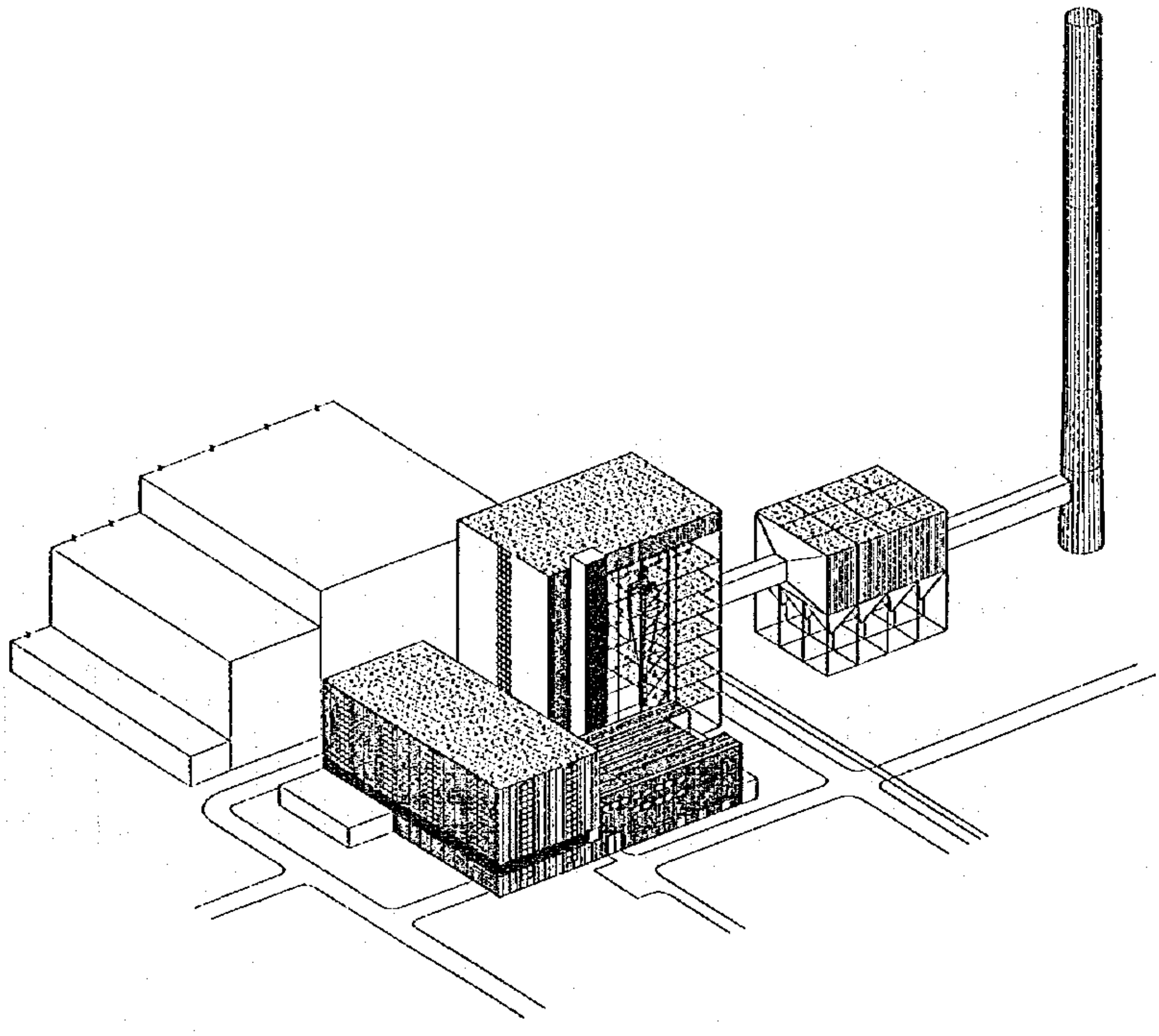

The New 150 MW Unit

The 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.
ÓMH	:	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 $\mu g/m^3$ 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 $\mu g/m^3$ or 150 ppb) is satisfied. The background concentration (contribution from other sources) itself exceeds the environmental standard for protected areas I (250 $\mu g/m^3$ 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

The Sajö Valley area is 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.

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.

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

(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.

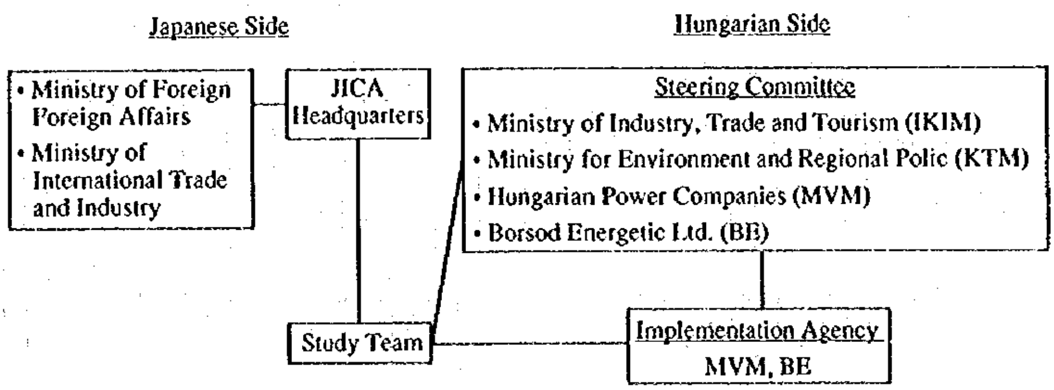
(3) Outline of the Study

The Study was carried out in the following 3 stages:

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

1.3 Organization for the Study

The general organization for the Study is as shown below.



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

Stage	Preliminary Investigation Stage				Detailed Investigation Stage								Feasibility Grade Design Stage					
Year	1996											1997						
Fiscal Year	1995		1996												1997			
Month	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7
Work in Hungary		First Study of Existing Facilities							Second Environmental Survey			Third Environmental Survey Economic & Financial Study Preliminary Design				Explanation of Draft Final Report		
Work in Japan	Preparation			First Identification of Ploblems Study Policy Planning						Second Preparation of Optimum Development Plan			Third Preliminay Design Environmental Impact Study Economic & Financial Analysis Preparation of Draft Final Report					
Completion of Report	▲ Inception				▲ Progress						▲ Interim			▲ Draft Final				▲ Final

Chapter 2

Background of the Project

Chapter 2 Background of the Project

2.1 Economic Situation in Hungary

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, thereafter, the structural reforms failed.

The new and current government led by the Hungarian Socialist Party, which took power through the election of May 1994, has been pushing ahead since, March 1995, with macroeconomic adjustment programs in which budget cuts and structural reforms are major elements. The growth in real GDP in 1996 is expected to be below 2.5 %, which was achieved in the previous year, in response to weaker markets both abroad and at home.

2.2 Situation of Energy and Electric Power

(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

Since the enactment of the new Privatization Act in 1995, the Government has been accelerating privatization of state-owned energy-related enterprises including power generation companies. 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.

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.

Although a certain portion of shares of MVM is sold to these private 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.

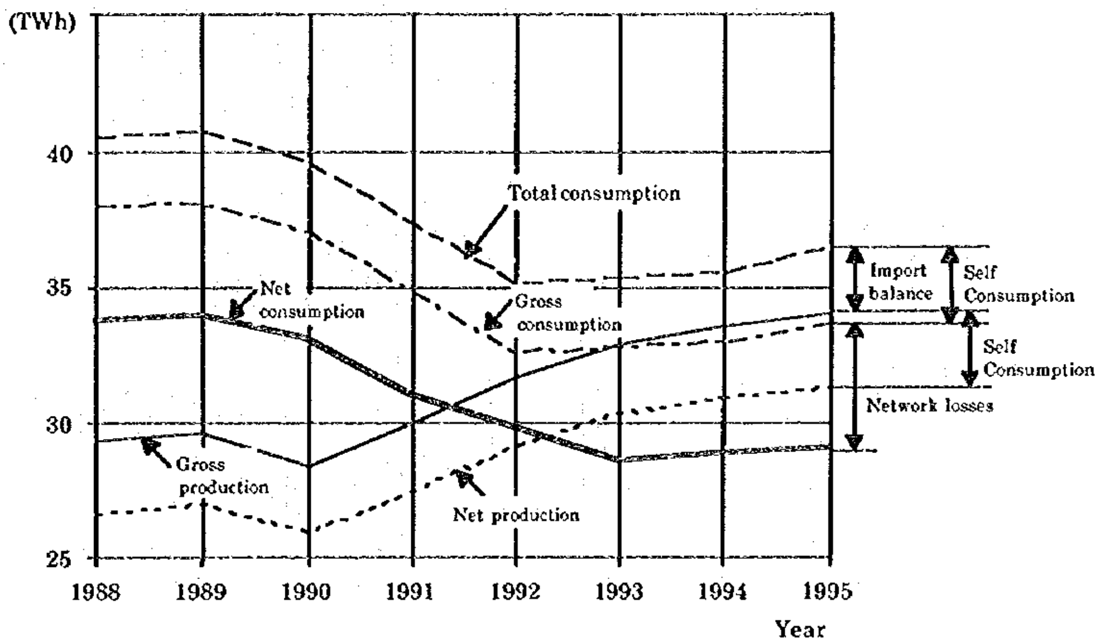
(2) Demand and Supply of Energy and Electricity

1) Total energy source

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.

2) Electric power generation and consumption

Figure 2.2.1 shows the trend of electric energy production and consumption in Hungary.



Source : MVM Statistical Data 1995, March 1996.

Figure 2.2.1 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.

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 %). 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 Outline of 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. Commissioned generation capacity in 1995 was 7,403 MW.

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. The power distribution is undertaken by the six power distribution companies in the respective regions.

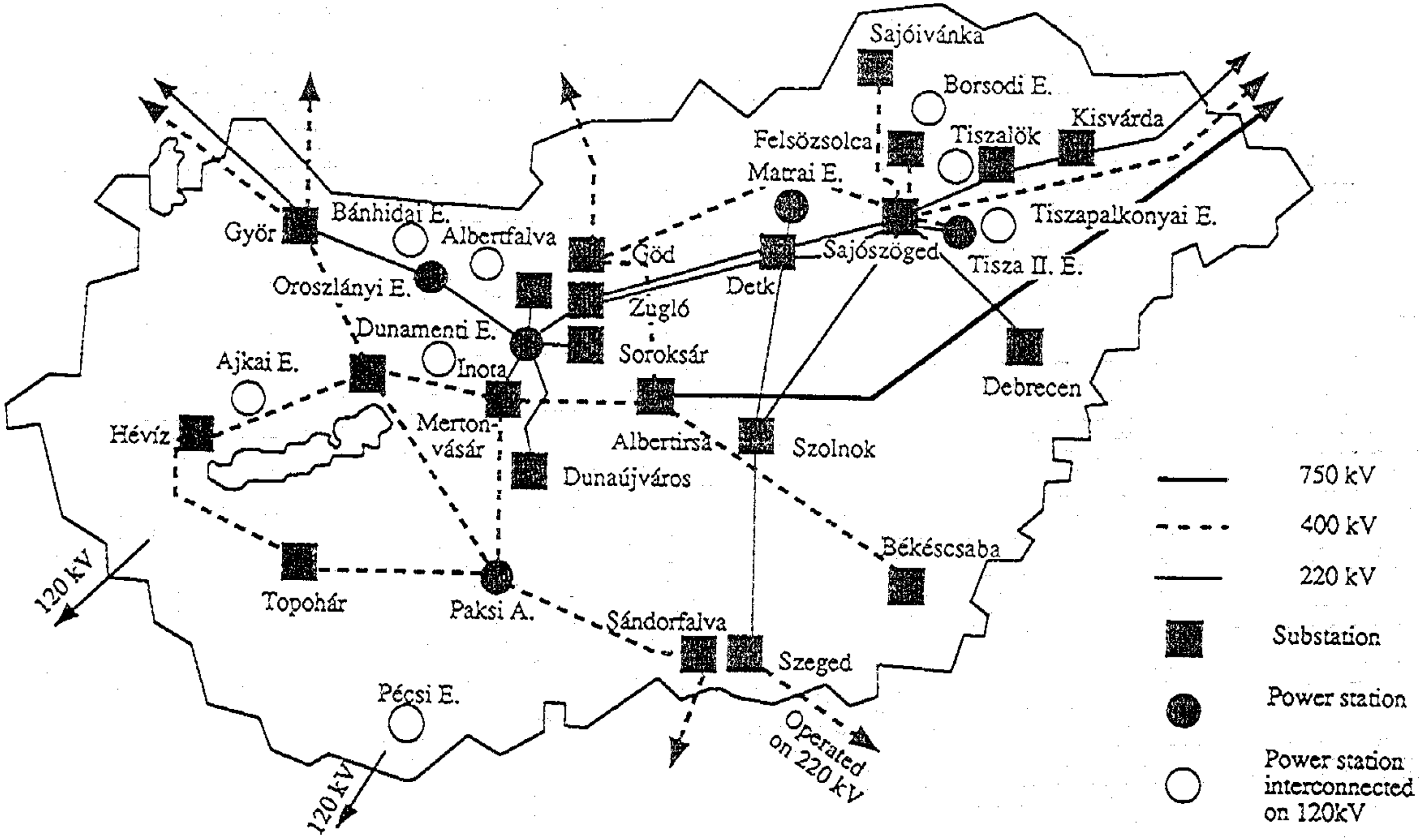


Figure 2.3.1 Basic Network System and Power Stations

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.

2.4 Projection of Electric Power Demand

The Hungarian Government expects 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.

As shown in Table 2.4.1, the electricity demand is expected to increase steadily even with the most pessimistic scenario. Since 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.

2.5 Outlines of Borsod Power Plant and Existing Development Plan

(1) Outline of the Power Plant

Borsod Power Plant was established in 1957. 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.

1) Boilers

There are 10 boilers of 100 t/h capacity. 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/m^3	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.

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) 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.

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 Steam pressure : 165/45 bar Steam temperature : 540/540 °C	Reheat type CFBC
Turbine	Rating output : 150 MW Steam temperature : 535/535 °C Steam pressure : 160/43 bar	Extraction, reheat, condensing type Casing: 3 (high/intermediate/low) 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.

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

(1) Power Generation Capacity of the New Unit

In the national power plant development policy of the Hungarian Government, construction of several 150 MW-class power units utilizing local coal is deemed to be necessary. 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 MWunit 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.

Considering such circumstances, the capacity of the new unit is determined to be 150 MW for the preliminary design in this Study. 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.

(2) Heat Supply Capacity

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 3.1.1.

Table 3.1.1 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 3.1.1 are very close to the actual figures of the latest years, 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

The following points were taken into consideration for the selection of 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

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

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

3) Yearly plant availability

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

4) Emission standards for the new unit

Table3.2.1 Emission Standards for Solid Fuel (2005)

Pollutant	Concentration (mg/m^3)
Soot & dust	50
CO	250
NOx as NO_2	400
SO_2 (382MWth)	872
HCl	100
HF	15

3.2.2 Selection of Boiler Type

The studies were made on two types of boilers: CFB boiler, as selected in the past F/S, and pulverized coal firing (PFC) boiler plus flue gas desulfurization (FGD).

(1) CFB Boiler

1) State of large-scale CFB boiler technology

There are three power plants in the world that use a CFB boiler of the evaporation capacity at 350 t/h or more firing low calorific lignite or brown coal: Texas-New Mexico Power Plant (TNP-One), Provence Power Plant, and Goldenberg Power Station. Features of CFB boilers in these power plants are shown in Table 3.2.2.

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

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 separation	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) Problems and solutions in application of CFB boiler in Borsod Power Plant

For application of the CFB technology in Borsod Power Plant, the following measures should be taken considering that Borsod coal is to be used as the main fuel.

Problem

Borsod brown coal has high ash content of 35~40 % and sulfur content of 2 % or more.

Solution

(a) Reduce total ash content by mixing with import coal of low ash content.
(b) Design appropriate capacity of external heat exchanger (EHE) according to the amount of ash generation.
(c) Delicately control the ash separation, recirculation, and EHE systems.
(d) Adjust the amount of limestone appropriately so as to reduce the amount of ash generated.

(2) PCF Boiler Plus FGD

PCF+FGD is a combined technology of PCF boiler, which have been in common use for several decades in Hungary, and FGD.

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

- High desulfurization efficiency (>90%)
- Desulfurization agent is limestone which is available everywhere in large quantities 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

(3) Selection of Boiler Type

The two alternatives for the boiler type (CFB+EHE and PCF+FGD) were comparatively analyzed. The major results are summarized in Tables 3.2.3 and 3.2.4.

The technology of CFB+EHE is judged to be more advantageous in both the initial cost and the running cost for the service life. Therefore, this technology will be adopted for the boiler.

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	Lignite, brown coal, hard coal, oil slate, wood chips etc. within very wide range of heating value	Lignite, brow coal, hard coal.
Size	0.1 to 40 mm, depending on design.	0 to 10 mm, min 75% is below 200 mesh.
Surface moisture content	Low, in order to avoid any trouble in fuel supply	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.	770 to 860 °C	1300 to 1500 °C
- Excess air	1.2 to 1.3	1.2 to 1.3
- Combustion efficiency	99%	99%
- Boiler efficiency	90.3 %	86 to 88 %
- Desulfurization	by using limestone in the combustion chamber	wet limestone-gypsum procedure downstream the boiler
- Ratio of desulfurization	> 90%	>90%
- Calcium/sulfur ratio	2.0 to 3.0	1.05 to 1.1
- Reduction in nitrogen oxide emission	Low combustion temperature with multi-stage air supply	Low NOx burners with multi-stage air supply
- Rate of load change	3%/min.	3%/ min.
- Minimum permanent load	Less than 40% of MCR	40% of MCR
- Other features	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%	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	Membrane wall, wear resistant wall on its lower part	Membrane wall
- Gas flow velocity	5 to 15 m/s	-
- Staying time in comb. chamb.	3 to 5 sec	1 to 5 sec
- Fuel supply	Fluidized transport from bin, charging into the combustion chamber or the bed ash return line	The pulverized and dried coal will be transported by means of the drying gas to the pulverized coal burners.
- Coal processing	Traditional, grinding, homogenizing in the combustion chamber.	Grinding, sieving, mixing, transport into raw coal bunker.
- Others	Boiler capacity can be increased by the number of cyclones.	Various firing systems depending on the ash- and moisture content of fuel
- Air supply	Complicated, uses various fans and blowers	

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

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 layout of turbine generator unit in the world including Hungary. This is the most reliable type of design having much experience of operation.

(2) Selection of Generator Type

The new 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

The location of the new unit to be constructed is an unused area at south-east of the existing main building. As the basic layout of the following facilities 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.

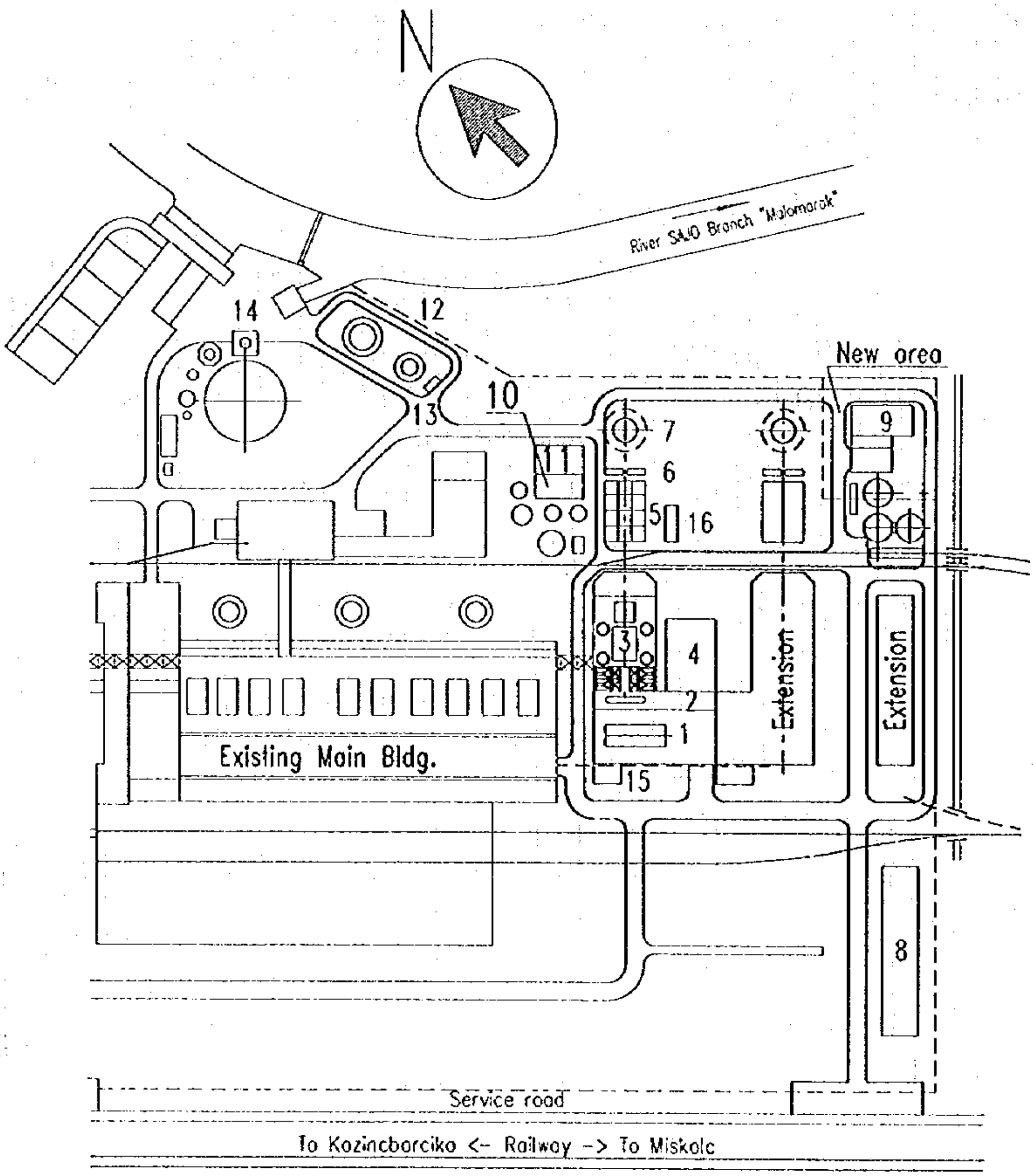
(a) Turbo-generator building and feedwater building
(b) CBF+EHE boiler of 460 t/h capacity
(c) Electric precipitator, induced draft fans and stack
(d) Multi-purpose building for electric equipment, control room and social facilities
(e) Wet cooling facility with pump building
(f) Electric power equipment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

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 m^2	48 x 45 = 2,160 m^2
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). Therefore, the T layout shown in Figure 3.4.1 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 3.4.1 Power Plant Layout of Version "T"

Scale
0m 25m 50m 75m 100m

3.5 Fuel and Limestone Supply Plan

3.5.1 Fuel Supply Plan

(1) Availability of Borsod Coal

1) Existing coal mines

In Borsod Power Plant, the mixture of brown coals from the mines of Lyuko, Feketevolgy and Putnok are mainly used at present. The characteristics of these three mines are as follows.

- Production is made by broad profile exploitation secured with up-to-date self-moving shields.
- Cutting is done by high performance cutting machines.
- Underground transportation is modern with a sufficient capacity without limiting coal extraction works
- The work at a coal face is done by the method called " supplementary work" .
- Many open drifts, gangways, stopes are further and further away from the entrance.
- Coal of the size smaller than +20mm is separated at the mine and the transferred to Berente Grading Station.

2) Minable reserves of Borsod brown coal

The minable reserves of Borsod brown coal are shown below.

Name of mine	Minable reserve	Heat value
Lyuko	28.0 Mt	11.0 GJ/kg
Feketevolgy	3.0	11.0
Putnok	3.0	12.0
Total	34.0	11.1

3) Coal production plan

The Government has guaranteed financing red-ink production of Feketevolgy and Putnok mines only until in 1998. In consequence, regional coal production of local mines will fall below 1,000,000 t/y by the year 2000.

The production from each mine before 2000 is shown below.

unit: 1,000 t/y

Name of mine	1997	1998	1999	2000
Lyuko	880	880	880	880
Feketevolgy	260	260	260	260
Putnok	480	480	480	480
Total	1,620	1,620	1,620	1,620

After 2000 the following production figures are expected at Lyuko mine.

2001-2010: 800 kt/y,
2011-2012: 500 kt/y

Its coal reserves will be exhausted thereafter.

It is possible to increase the amount of coal supply to Borsod Power Plant by 15-20% from the present level by reducing the amount of coal supply to domestic use.

4) Development of a new coal mine

The development of Dubicsany coal mine was started in 1980, but interrupted under the economic and social reforms at the beginning of the 1990s. Since then, the development has not been resumed due to the following problems pointed-out by experts:

- Tectonics, especially smaller faults must be investigated.
- Water breaking in the mine, and other risks must be clarified.
- A sufficient environmental impact study is necessary.
- Further investment must be actuated.

Some characteristics of Dubicsany mine are shown below:

- Exploitable coal resources : 70,122,000t (Approx. 5% of the equally qualified brown coal resources of Hungary)
- Depth of coal bed : 53~306m (average depth: 206m)

- Average thickness of coal seam :3.2m
- Net heat value :10.26~14.14 MJ/kg

5) Coal price at Borsod Power Plant

507.00 HUF/GJ (1997)

6) Problems of Borsod coal resources

Unless new mines are developed before 2012, Borsod coal will be exhausted. For this reason, it is necessary to resume the development of Dubicsany mine before 2007, or secure necessary supply from neighboring mines.

(2) Procurement of Import Coal

Power plants are not allowed to use imported coal for protecting domestic coal mines, and have strictly observed this regulation. However, normal coals can be imported for boilers of newly installed units. The maximum demand is 200,000 tons/y.

1) Estimated import coal price at the Power Plant

In case of coal from overseas, the price of coal coming from certain countries is determined in proportion to the heat value. Around 50% of the price of import coal at power plants is the transportation cost, and this percentage increases in inverse proportion to the heat value. In the case of coal imported from Central Europe or the CIS countries, the percentage of the transportation cost is smaller than that of coals from other areas. Therefore, this case is advantageous for the Borsod project.

More accurate price figures will be available only after the actual delivery contract is concluded, since the price depends significantly on several other factors as well (contracted quantity, contract period, terms of payment, etc.). On the basis of the study of several cost components of 1996, the prices of import coals at Berente grading station (Borsod Power Plant) is estimated as shown in Table 3.5.1.

Table 3.5.1 Price of Imported Coal at Borsod Power Plant (1997)

Place of origin	Gross Cal. Value	Route				
		I.	II.	III.	IV.	V.
	GJ/t	HUF/GJ				
Australia	28.1	524	460	413	-	-
South-Africa	26.8	496	429	380	-	-
U.S.A.	28.1	468	404	358	-	-
Columbia	28.1	468	404	358	-	-
Indonesia	28.1	512	449	402	-	-
Poland	26.8	-	-	-	281	-
Czech Republic	26.8	-	-	-	354	-
CIS countries	26.8	-	-	-	-	318

Routes:
I. Rotterdam - water-carriage (DMR channel) - Port Budapest - railway transport - Berente
II. Rijeka port - railway transport -Berente
III. Constanta - water-carriage (Danube) - Dunaújváros - railway transport - Berente
IV. Bánréve - railway transport - Berente
V. Záhony - railway transport - Berente

2) Design price of import coal

On the supposition that the coal is imported from Poland, Czech and CIS countries, the net heat value and the price at Borsod Power Plant are assumed to be 25.6 GJ/ton and 318 HUF/GJ, respectively.

(3) Design Fuels

1) Coal

The coal types and mixtures to be considered are as follows.

Case a : 100% Borsod brown coals mixture
Net heat value: 9.0 MJ/kg
(when better quality portions are supplied to domestic use)

Case b : 50-50% mixture of Borsod brown coal and imported hard coals on the base of heat valve
Net heat value: 13.32 MJ/kg
(74% brown coal and 26% hard coal on the weight base)

Case c : 100% Borsod brown coals mixture
Net heat value: 11.30 MJ/kg
(when better quality portions are also supplied to the Power Plant)

Case d : Lowest quality Borsod brown coal
Net heat value: 7.56 MJ/kg

The coal to be used in the newly installed CFB boiler is assumed to be of Case b. Tables 3.5.2 and 3.5.3 show the characteristics of coals to be used.

Table 3.5.2 Characteristic Data of Coals to be Used

Characteristics		Borsod brown coal	Imported hard coal
Net heat value	(MJ/kg)	9.0	25.6
Grain size	(mm)	0 to 20	0 to 20
Ash	(%)	36.45	11.25
Moisture	(%)	24.8	9.5
Carbon	(%)	24.8	
Hydrogen	(%)	2.17	
Oxygen	(%)	9.08	
Nitrogen	(%)	0.5	
Sulfur	(%)	2.2	0.8

Table 3.5.3 Design Coal

Borsod/import coal	50:50 heat base
Net heat value	13.32 MJ/kg
Ash	29.9 %
Sulfur	1.8 %

2) Natural gas and fuel oil

The characteristic data of natural gas and fuel oil to be used are summarized in Tables 3.5.4 and 3.5.5.

Table 3.5.4 Characteristics Data of Natural Gas to be Used

Components	Content
c1 (% vol.)	98.51
c2 (% vol.)	0.32
c3 (% vol.)	0.13
c4 (% vol.)	0.05
c5 (% vol.)	0.02
c6 (% vol.)	0.01
CO_2 (% vol.)	0.04
N_2 (% vol.)	0.92
Relative density at 15 °C	0.563
Net heat value (MJ/m^3)	33.94

Table 3.5.5 Characteristics Data of Fuel Oil to be Used

Light fuel oil (FA-60/80)		
Viscosity at 20 C° (minimum) at 100 °C (maximum)	 (mm^2/s) (mm^2/s)	 8 4.4
Flash point by Cleveland's method, min.	(°C)	101
Pour point	(°C)	-20
Sulfur content	(%)	below 0.2
Relative density at 15 C°		1.005
Heat value	(MJ/kg)	41.0

3.5.2 Limestone Supply Plan

(1) Quality and Quantity Requirements

1) Quality requirement of limestone

a) Composition

The most important component of limestone as a desufurization agent is $CaCO_3$, whose content should be at least 93%.

b) Grain size

The raw limestone supplied from mines is crushed at the Power Plant. However, for the secured operation, the Power Plant will have also a facility to receive limestone grist.

Raw limestone: 0 - 50mm
Limestone grist for CFB: 0 - 3.0mm

2) Limestone consumption in CFB boiler

Qd = 442 t/d

(2) Procurement Possibility

In the Borsod area, there are three supply sources of limestone. These are as follows;

- Hejôcsabai Mészkôfeldolgozó Rr. (HCM) Hejôcsaba:
  30km away by railway from the Power Plant.

- Bélapátfalvai Cement és Mészmű Rt. (BCM) Bélapátfalva:
  58km away by railway from the Power Plant.

- OMYA Eger Mészkőfeldolgozó és Értékesítő Kft. (OMYA) Eger:
  76km away by railway from the Power Plant.

(a) It is considered that limestone from all of above can satisfy quality requirements.

(b) All of above mines are required new development in order to supply Borsod Power Plant with a sufficient amount of limestone with a suitable particle size.

(3) Procurement Costs

The FOB prices of limestone were estimated as follows by referring the price of the limestone from the Transdanubian mine located near Transdanubian Power Plant which has a modernization program similar to that of Borsod Power Plant.

a) Raw limestone (0 to 50 mm), loaded into wagons : 360 to 720 HUF/ton
b) Limestone grist (0 to 3 mm), loaded into wagons : 1,300 to 1,600 HUF/ton

(4) Railway Transport

In consideration of quantity and environmental protection, closed type railway wagons will be used.

(5) Limestone Price to be Expected at the Power Plant

Based on the above, the limestone prices at the Power Plant are as follows:

(a) Raw limestone (0 to 50 mm) : 900 to 1,400 HUF/ton
(b) Limestone grist (0 to 3 mm) : 1,700 to 2,800 HUF/ton

3.6 Slag and Fly Ash Transport System

(1) Existing Slag and Fly Ash Transport Facilities

For transporting slag slurry and fly ash from the slurry center to the storage area, two systems established at different times are provided in the Power Plant.

1) Thin slurry method

The thin slurry system was reconstructed during 1988 to 1990. Future use involves the problem of slurry water infiltrating the ground. For the amount of the slurry water infiltrating the ground associated with the storage of slag and fly ash according to this method, North Hungary Environmental Protection Inspectorate (EKF) and North Hungary Water Management Authority instructed that the amount of the infiltrating water be not greater than 10 m^3/day for the storage area of 34.2 ha. Accordingly, it is practically prohibited to store the sludge using this method.

2) Thick slurry method

For solving the above problem, a thick sludge technique was developed in Hungary, and its operation was started in the Plant in 1995 to 1996. In a slag and fly ash storage area, thick slurry is solidified by the same method of solidifying concrete. The technique reduces the amount of ash scattering from the sludge storage areas and the amount of water infiltrating into the soil.

According to the explanation by Borsod Power Plant, it completed trial runs using this technique and started full-scale operation in the summer of 1966. However, there still remain problems to be solved including the permeability of water.

(2) Possibilities for Slag, Bed Ash and Fly Ash Transport

In principle, there are three ways of transporting combustion residues to the disposal area.

1) Vehicle
2) Conveyer belt system
3) Extension of the existing pipeline system

(3) Comparison of the Transport Methods and Conclusion

It seems that the thick slurry system using pipelines is in trial run at present. As shown in Table 3.6.1, this thick slurry system has many merits in comparison to other systems. Based on this, the problem of the slurry water infiltrating into the ground should be solved by using impermeable sheets and water recycling systems in slag and fly ash storage areas, and this pipeline system should be used for the transport.

Table 3.6.1 Comparison of Transport Methods for Combustion Residue (Transport between the power plant and the slurry area)

Concern	Transport by truck	Transport by conveyer	Transport by piping
Operation time	2 shifts	2 shifts	continuous
Investment cost	very high	very high	moderate
Maintenance demand	high	moderate	high
Operation cost	very high	moderate	moderate
Staff*	30 persons	18 persons	12 persons
Deposit watering	necessary	necessary	not necessary
Deposit solidification	none	none	expectable
Watertight block	not necessary	not necessary	necessary

* Only in the moisturizers and the slurry center

3.7 Renovation of Existing Facilities

3.7.1 Boilers

(1) Existing Boilers

At present, in Borsod Power Plant, there are eight Borsod-100-M type boilers and two Borsod-100-R type boilers constructed by MHD. These are steam generators burning pulverized coal (100t/h steam), equipped with gas and fuel-oil auxiliary burning facilities.

(2) Consideration of Renovation Plan for the Existing Boilers

1) Selection of the boilers to be renovated

Renovated existing boilers will supply heat in accordance with the agreements with nearby enterprises and local governments. Four of the existing boilers will be renovated to conform the heat demand. Judging from the boiler conditions, boilers No.5, 7, 9 and 10 will be renovated.

2) Method for the renovation

Two alternatives are considered for renovation of four existing boilers.

i) A semi-dry, water-saving type desulfurization system is installed to existing pulverized coal firing (PCF) boilers to decrease sulfur oxides.

ii) Gas or fuel oil is burned in boilers with the decreased combustion chambers volume (heat transfer area).

a) PCF+flue gas desulfurization (FGD)

Considering the following characteristics, a semi-dry, water-saving type FGD system was selected for examination.

i) It is possible to recycle unreacted lime collected from circulating fluidized bed (CFB) boilers.

ii) Less industrial water is consumed.

In a semi-dry desulfurizer system, SO2 in exhaust gas is contacted by slurry containing sprayed fresh slaked lime and absorbed by the slurry. Main products from this reaction are calcium sulfate and calcium sulfite.

b) Natural gas and fuel oil combustion

Gas or fuel-oil combustion requires reduced area of heating surface. However, it no longer requires any electrostatic precipitator (EP), flue gas desulfurizer (FGD) or ash disposal facility. This is advantageous for securing environmental protection. It is also possible to shorten the time of reconstruction and associated outage.

i) The bottom membrane water-walls and funnels of existing boilers are cut off, and equipment for bottom ash and coal combustion is removed.

ii) New membrane water-walls are welded air tight to existing vertical membrane walls. In addition, two alternative burners are installed on the optimum positions.

iii) Exhaust gas recycling fans are newly installed.

iv) Economizers and air preheaters installed on the second pass and third pass are adjusted to the optimum positions.

The above improvements guarantee the boiler efficiency of above 90%.

(3) Selection of Boiler Renovation Method

Comparisons of above-mentioned two boiler types are shown in Table 3.7.1. It is clear that natural gas and fuel-oil combustion is superior to that of PCF+FGD.

Table 3.7.1 Comparison of Boiler Renovation Methods

Item	PCF+FGD	Gas and Oil Combustion
Main facilities	To install desulfurizer	To remove bottom of furnace To remove coal firing system To install EGR system To install gas/oil burners
Environmental protection facilities	Electrostatic Precipitator Semidry Desulfurizer	Low-NOx Burner
Ash disposal facility	Original	Not necessary
Fuel supply facility	Original	Extension of gas supply system To install fuel oil tanks
Operation technology	Though operation boiler is same, operational technology for FGD will be needed	Even conventional operation technology will be applied becouse of the automation
Environmental considerations	Not to exceed the Emission Standard in 2005	Not to exceed the Emission Standard in 2005
Facility cost	62,710,000 USD	46,818,000 USD
O & M cost	3.2%/y	2.5%/y
Operators	70persons	55 persons
Overall Evaluation	Fair	Good

3.7.2 Operation Plan of Turbines

For the operation plan of turbines corresponding to the reconstruction of four boilers, the following two cases were examined.

Case 1: Turbines No. VI, VII, and X will be used for steam supply, and No. V (and No. VII if necessary) will be used for heating. There will be no more condensing power production.

Case 2: A new 32 MW double extraction (29 bar and 15 bar) condensing type turbine will be introduced to supply steam and power, and No. V and VII turbines will be used for heating

By comparing above cases, Case 2 has following advantages over Case 1:

(1) Long-term supply of power and heat is ensured by the installation of the new turbine.

(2) The new turbine can be switched to the existing 40 MVA generator.

(3) The present income structure of Hungarian power plants makes this scenario more advantageous.

By considering above, Case 2 has been selected as the operation plan of turbines.

Chapter 4

Preliminary Design of the New Unit

Chapter 4 Preliminary Design of the New Unit

4.1 Main Components and Plant Layout

Main components of the new 150 MW unit are as follows. The layout in the whole plant area is shown in Figure 4.1.1. The main components are located next to the south-east part of the existing plant.

- Boiler system (including a electrostatic precipitator, induced draft funs etc.)
- Turbine system
- Generator and auxiliary electrical equipment
- Imported coal receiving and storage, coal mixing (domestic and imported coal), coal feed system
- Limestone receiving, storage, girding and feed system
- Fuel oil tanks and pumps (including fuel oil piping)
- Slag and fly ash handling system
- Fresh water supply system
- Cooling water system (including a cooling tower)
- Feed water treatment and wastewater treatment system
- Transformers and switch gears
- Auxiliary power supply system, air conditioning system, air compressors etc.
- Instrumentation and control system
- Buildings (for boiler, turbine, heater and central control system etc.)
- Stack
- Transportation facilities (rail network and roads inside the plant)

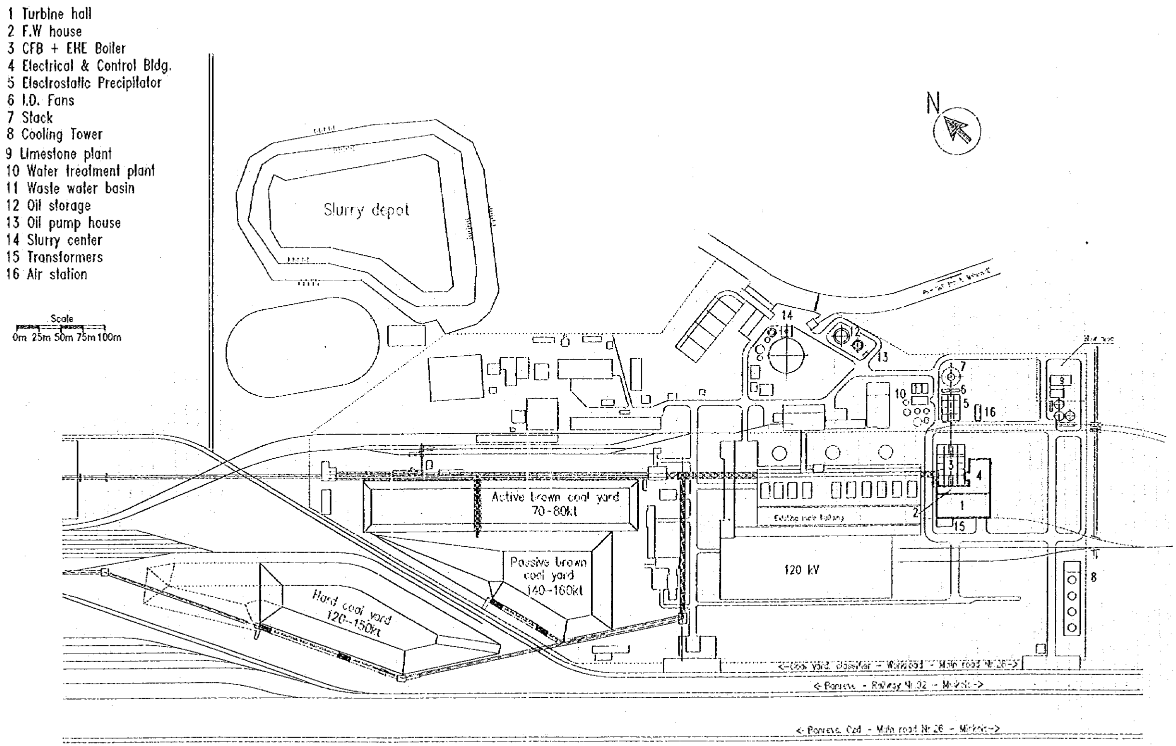


Figure 4.1.1. General Plant Layout

4.2 Boiler System

(1) Basic Data for Planning

Based on the results of the study in Chapter 3, a circulating fluidized bed (CFB) boiler is used for the new unit. The basic data of the boiler for planning is as follows. Top and sectional views of the proposed boiler are shown in Figures 4.2.1 and 4.2.2, respectively.

Unit capacity:	150 MWe
Type of boiler:	Circulating fluidized bed (CFB+EHE)
Steam parameters:	
- Max. steam generating capacity (MR):	127.8 kg/s (460 t/h)
- Max. permanent steam generating capacity (MCR):	126.1 kg/s (454 t/h)
Live steam parameters at boiler outlet:	
- pressure	165 bar
- temperature	540 °C
Reheated steam parameters:	
- mass flow	117.9 kg/s (424 t/h)
- outlet pressure	45 bar
- outlet temperature	540 °C
Steam extraction between the reheater stages:	
- mass flow	max. 19.4 kg/s (70 t/h)
- outlet temperature	420 °C
Feed water temperature at ECO. inlet	243 °C

Emission limits of air pollutants in the dry flue gas at 273 °K and 101.3 kPa with 6% oxygen content:

- SO_2:	max. 400 mg/Nm^3
- NOx:	max. 200 mg/Nm^3
- Dust:	max. 50 mg/Nm^3

(2) Major Specifications

1) Boiler facilities

Combustion chamber	Natural circulation, water cooled, welded membrane wall structure

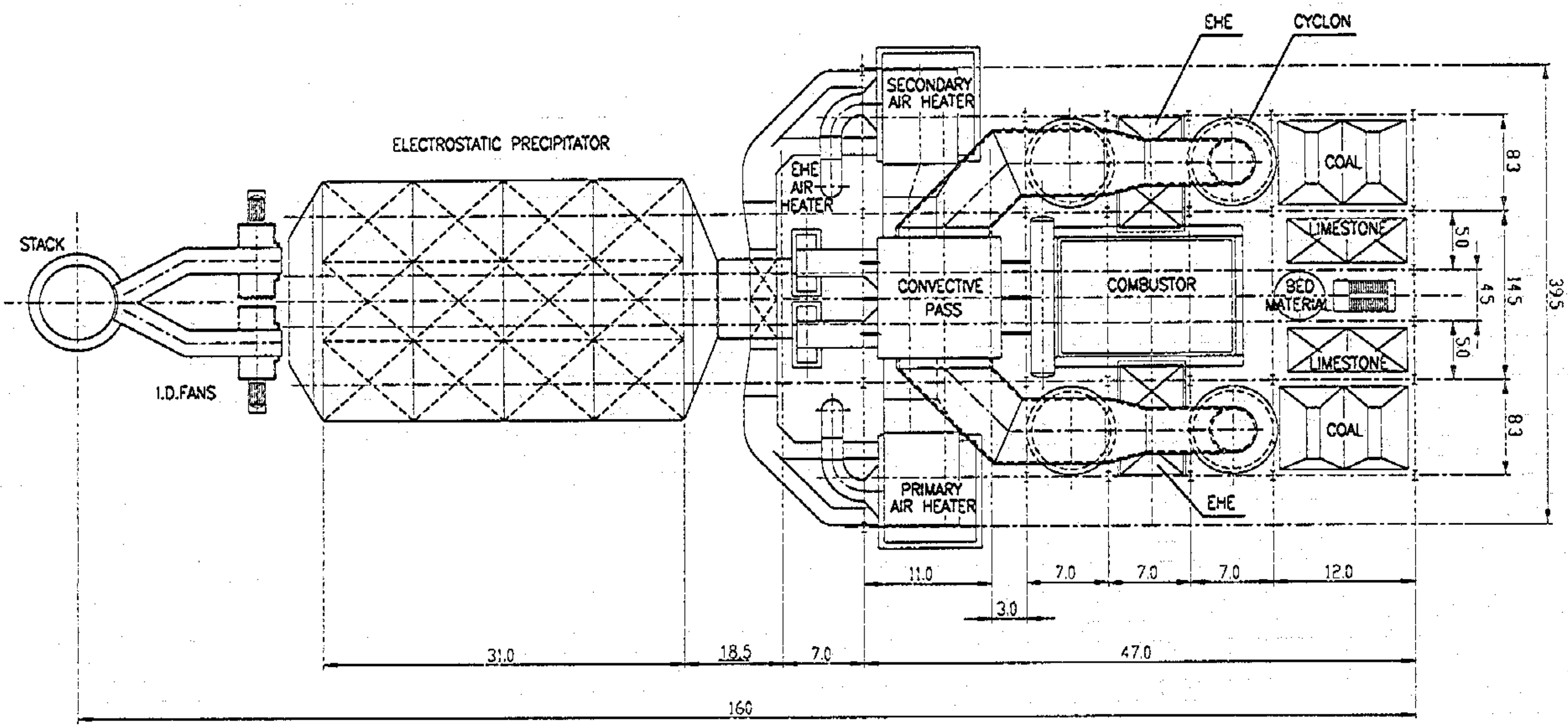


Figure 4.2.1 Top View of Boiler System (CFB + EHE)

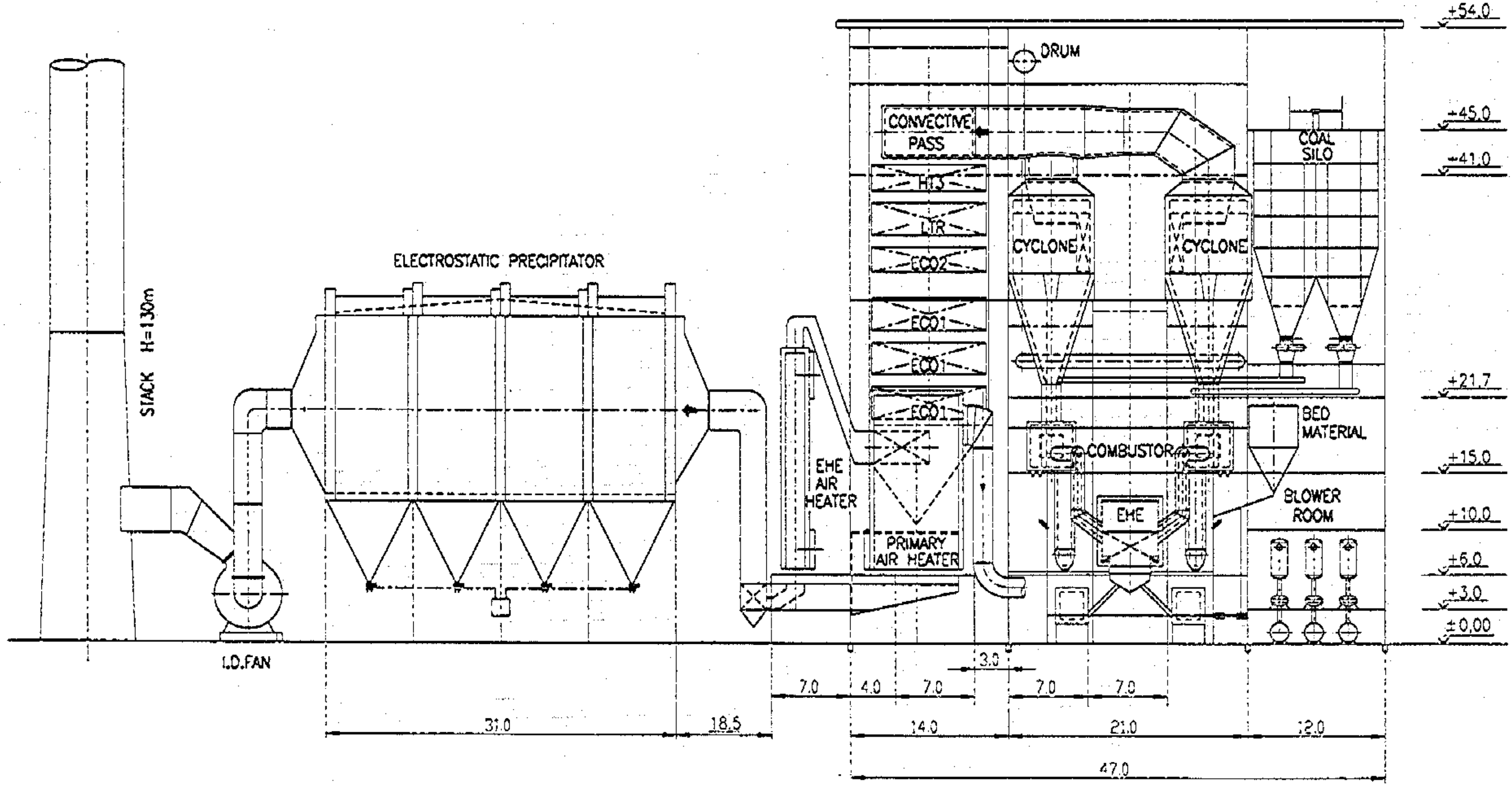


Figure 4.2.2 Side View of Boiler System (CFB + EHE)

Drum	Single-drum, with drop separator, welded structure
Cyclone	Centrifugal separator
	Efficiency: ≥ 99.5%
Bed ash circulating system	External fluidized heat exchanger
Superheater	Heat transfer by means of convection
Reheater	Heat transfer by means of convection
Fuel pre-heating	Blank pipe
Boiler casing	Corrugated steel sheet
Air preheater	Regenerative
Steam heated air heater	Fine-ribbed
Soot blower	Steam injection type with automatic or manual operation
Air and flue duct	Steel plate, welded structure

2) Coal and limestone supply system

Coal bunker	Steel plate with water resistant cover
	Quantity: 4 units
	Capacity: 18 hours of operation at MCR load
Coal feeder	Trough-chain conveyor
	Quantity: 4 units
	Capacity: 110 tons/hour in total
Limestone bin	Steel plate
	Capacity: 1 day of operation at MCR load
Limestone grist fluidizing compressor	
	Screw type compressor
	Capacity: 2300 m^3/h

3) Gas/Oil fired equipment

Ignition burners	Burner with electric ignition
	Capacity: 15% of MCR in total
Main gas burners	High pressure gas burner
	Capacity: 100% of MCR in total
Oil burners	Steam atomizing gun
	Capacity: 30% of MCR in total

4) Air supply equipment

Primary air fan	Centrifugal
	Quantity: 2 units (260%) with inlet-side AH
Secondary air fan	Centrifugal
	Quantity: 2 units (260%) with inlet-side AH
Flue gas fan	Centrifugal
	Quantity: 2 units (260%) with cooled bearings
Bed ash fluidizing blower	Blower
	Quantity: 2 units

(3) Firing Equipment

1) Design fuel

The quality of solid fuel for the CFB boiler can be chosen from a relatively wide range. Basics of planning and environmental aspects taken into consideration, Borsod brown coal is mixed with imported hard coal by 1:1 on the heat value basis. The characteristics of these coals are summarized in Table 4.2.1.

2) Combustion

In the fluidized free board, the coal is burnt at a temperature of about 850 °C. The fluidized media are coal, bed ash and limestone. Air and flue gas serve as fluidizing media. Part of the air (the primary air) enters at the bottom of boiler, while the other part is fed at the conical part of the combustion chamber. The low temperature in the combustion chamber and the multi-stage air inlet have a favorable effect on supression of thermal NOx generation.
Sulfur in the fuel is fixed through the reaction with the limestone added, and collected from exhaust gas by 90 % or more.

3) Bed ash

The bed ash is separated from the combustion products, that leave the fluidized free board, in the external cyclones. The bed ash thus separated is fed back directly on the one hand, and through the external heat exchanger (EHE) on the other hand, to the combustion chamber.

Table 4.2.1 Characteristics of Coals

Characteristics	Borsod Brown Coal	Imported Hard Coal
Net calorific value, Hi, MJ/kg	7.56 to 9.16 (avg. 9.0)	avg. 25.6
Grain size	0 to 20	0 to 20
Coal analysis		
Ash %	36 to 42.8 (avg. 36.45)	6 to 16.5 (avg. 11.25)
Moisture %	21.6 to 25.7 (avg. 24.8)	6 to 13 (avg. 9.5)
Average carbon %	24.8	
Average hydrogen %	2.17	
Average oxygen %	9.08	
Average nitrogen %	0.5	
Average sulphur %	2.2	(avg. 0.8)
Ash analysis		
SiO_2 %	avg. 51.0	40 to 80
Al_2O_3 %	avg. 18.8	14 to 37.5
Fe_2O_3 %	avg. 13.2	2.5 to 20
MgO %	avg. 4.2	0.2 to 5.5
CaO %	avg. 8.0	0.54 to 12
Na_2O %	avg. 0.8	0.1 to 2.2
K_2O %	avg. 2.2	0.3 to 5
SO_3 %	avg. 1.8	0.3 to 8
TiO_2 %	-	0.6 to 3.1
P_2O_5 %	-	0.01 to 1.5

4) High capacity natural gas burners

In the case of prolonged failure of the coal supply line or the fuel residue removal system, or the capacity of coal bunkers or ash storage is insufficient for the continuous coal firing, the full (100%) steam generation capacity of the boiler system is maintained by natural gas firing.

(4) Desulfurization System

Crushed limestone is added by means of a pneumatic system. The daily bin contains crushed limestone sufficient for 24 hours of operation. It is fed automatically according to the desired rate of desulfurization.

(5) Steam System

The boiler is of natural circulation and the membrane wall design, suspended from above, expanded freely downwards. In the second pass, two superheaters for live steam and one superheater for reheated steam are mounted, with one stage of each superheater submerged into the cooler of the external bed ash.

(6) Bed Ash Handling (Figure 4.2.3)

The bed ash cooler is connected to the lower part of fluidized free board for removal of excess bed material. The bed ash is cooled down to 130 °C by air and cooling water.

(7) Flue Gas System

Flue gas from the free board enters into the cyclone first for separation of the bed ash. The flue gas that containing fly ash is cooled down to 130 °C by heat exchange at convection surfaces of the boiler, economizers, and air preheater, and flows into the electrostatic precipitator (EP).

Flue gas from the EP is directed into the new stack. The O_2, CO, NOx, SO_2 and dust concentrations are continuously measured.

(8) Emission of Air Pollutants

Based on preliminary data acquired from suppliers, the concentrations of pollutant emissions expected in the dry flue gas at 273 °K, 101.3 kPa, and 6% oxygen content are as follows:

SO_2:	max.	400 mg/Nm3
NOx:	max.	200 mg/Nm3
Dust:	max.	50 mg/Nm3

The design mixed coal has a heat value of 13.32 GJ/t and a sulfur content 1.8%. Therefore, supposing that the rate of desulfurization is 90%, the SO^2 concentration in exhaust gas is 694 mg/Nm^3. This figure meets 872 mg/Nm^3, the emission standard applicable to the new 150MWe unit (382MWth).

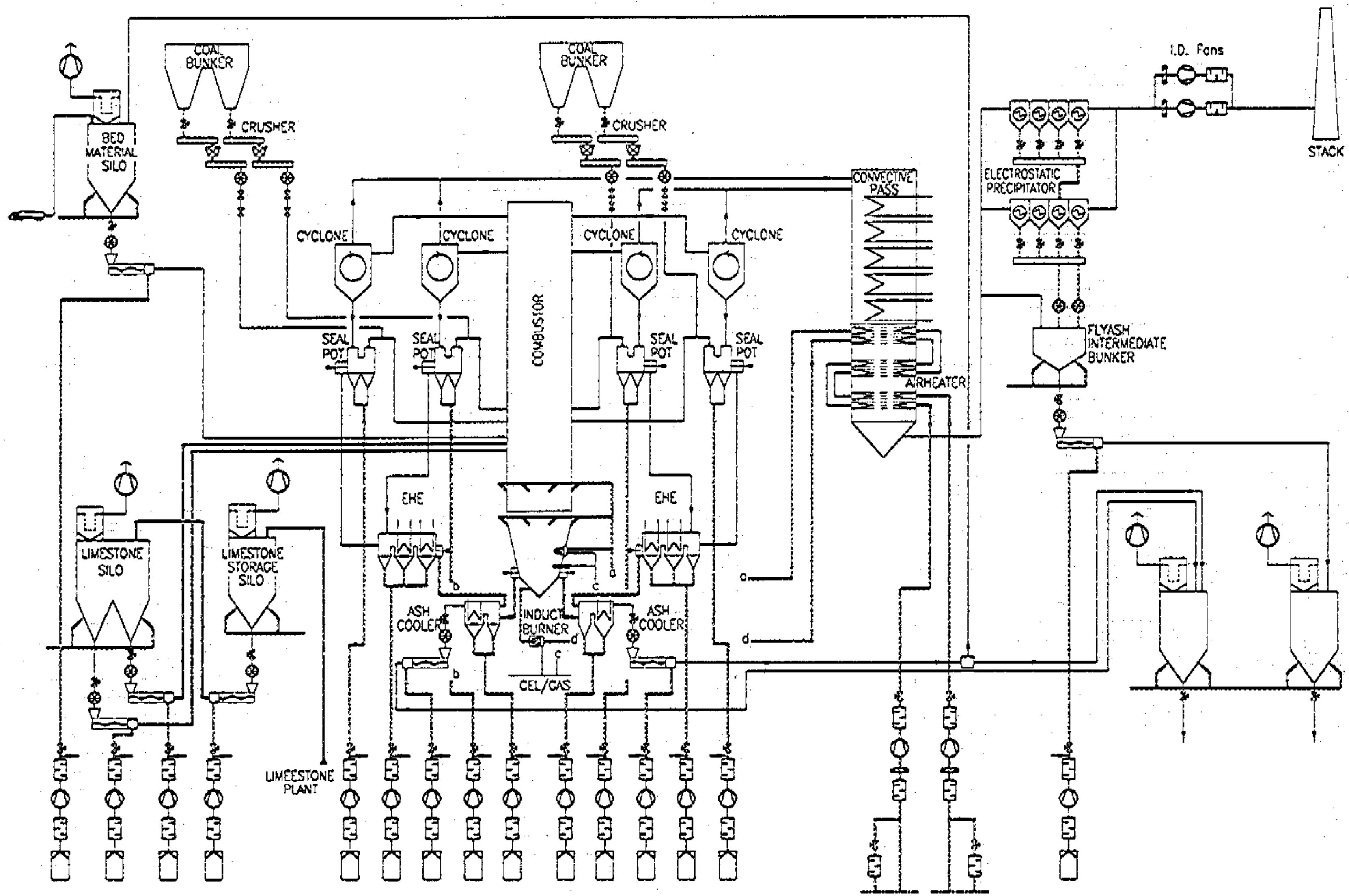


Figure 4.2.3 Boiler-solid Supply System

4.3 Turbine and Generator System

(1) Steam Turbine

1) Basic Design Data

Basic design data of steam turbine are as follows.

Type: Three-housing of condensing and reheating operation with both controlled and uncontrolled extraction

Rated capacity:
150 MW at the generator terminals in condensing mode

Steam parameters at turbine inlet:

Main steam pressure at turbine inlet:	160 bar (abs)
Main steam temperature at turbine inlet:	535 °C
Reheated steam pressure at turbine inlet:	43 bar(abs)
Reheated steam temperature at turbine inlet:	535 °C

Outlet pressure:
0.07 bar(abs) under the design condition
0.09 bar(abs) at rated load and +30 °C ambient temperature

Speed: 3000 rpm

Control system:
Electro-hydraulic conforming UCPTE

The flow diagram of steam/water system is shown in Figure 4.3.1.

The rated output of the steam turbine is 150 MW on the generator terminals. The output of the turbine in condensing operating mode and with heat output is shown in Table 4.3.1.

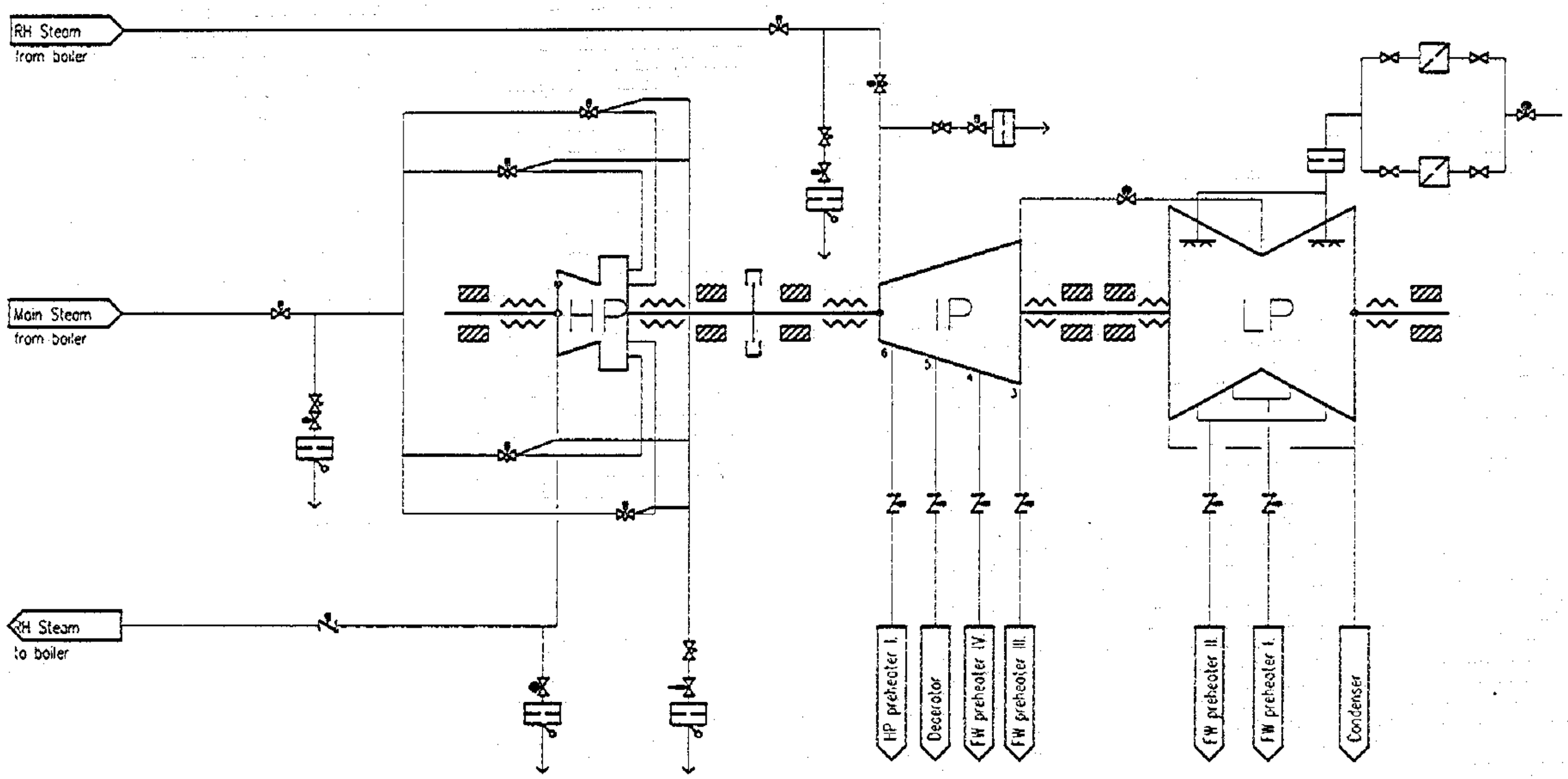


Figure 4.3.1 Steam Water System

Table 4.3.1 Steam Turbine Output

Operational condition / Parameter		Pure condensing operation				With heat output			
		a	b	c	d	a	b	c	d
Output on generator terminals	MW	150.0	112.5	152.9	147.7	122.0	124.5	48.6	48.2
Electric output	MW	137.0	101.3	139.8	134.8	110.3	112.7	40.5	40.0
Total heat output	MW					130.0	123.0	10.0	5.0
Heat transfer in the condenser	MW	181.4	130.0	178.5	183.8	88.1	91.9	56.7	61.6

Note:
Condensing operating mode
a. +15 °C ambient temperature (the above design condition)
b. Optimum load at 75%
c. Maximum load at -15 °C ambient temperature
d. Maximum load at +30 °C ambient temperature
With heat output
a. Maximum heat demand during winter:
Max. load at -15 °C ambient temperature
b. Heat demand during winter:
Max. load at -5 °C ambient temperature
c. Heat demand during summer:
Min. load (30%) at +15 °C ambient temperature
d. Minimum heat demand during summer:
Min. load (30%) at +30 °C ambient temperature.

2) Auxiliary equipment of steam turbine

Auxiliary equipment of steam turbine is as follows.

- Condenser: Horizontal, single flow type with condensate sink and condensate cleaning system
- Feed Water Heaters
- Lubrication and Regulator Oil System
- Steam Turbine By-pass System
- Condensate Pump

(2) Generator

The generator is a three-phase generator coupled directly with the turbine shaft and cooled by air/water heat exchanger.

Rated capacity:	187.5 MVA, cos fi 0.8
Rated voltage:	15.75 kV ±5%
Rated frequency:	50 Hz
Rated speed:	3000 rpm
Relevant standard:	IEC 34

The excitation equipment is of static type, with duplex power supply. The continuous power supply is ensured by means of automatic switch over between two feed lines.

4.4 Fuel Supply and Handling System

4.4.1 Coal Supply System

(1) Design Condition

1) Coal consumption

The maximum coal requirement of the Power Plant is as follows:

• Boiler load:	1 x 460	t/h
• Heat input with fuel:	382	MWth
• Coal consumption:	103.2	t/h
Borsod brown coal:	76.4	t/h
Import hard coal:	26.8	t/h

2) Capacity of coal transporting facility

For determining the delivery capacity, the following conditions are applied: 8 hours operating time and 75 % efficiency. Therefore, the delivery capacity necessary for the coal handling system is calculated as follows.

(24 h x 103.2 t/h) / (0.75 x 8 h) = 413 t/h

Based on the above the transporting capacity is determined to be 600 t/h.

5) Required days of coal reserve

Power Plant coal stockyard: 30 days
External coal stockyard: 60 days

6) Daily storage capacity of the coal bunkers in the boiler house

The net volume of the coal bunkers for the boiler is 650m^3. Therefore, the total storage capacity of the bunkers is

4 x 650 m^3 x 0.8 ton/m^3 = 4 x 520 t = 2,080 t

This capacity is enough for 20 hours of continuous service without recharging.

4 x 520 t / 103.2 t/h = 20 hours

(2) Rating Data of the Coal Handling System

The layout of the coal transporting system is shown in Figure 4.4.1 and the flow diagram of the coal receiving, storing, mixing and delivery system is shown by Figure 4.4.2.

1) The existing parts of the coal system require full renewal, and such renewal can make them fit for further 30 years of operation.

2) In order to provide a uniform strength to the delivery system, the capacity of discharge conveyors No. 11 and 16, which are on the crane bridge, must be raised to 600 tons/h.

3) The 320 t/h pickup capacity of the crane bridge is not sufficient, therefore feeding capacity from the stockyard within the Power Plant's fences has to be increased by installing a pickup system that is independent of the grabbing crane.

4) Hard coal and brown coal mixing is made during feeding, by adding hard coal to the brown coal arriving on the belt conveyor. Based on 16 hours of charging time and 75% of delivery efficiency, required hard coal delivery capacity becomes 112 tons/h.

5) Due to its low volatile matter content, hard coal is not spontaneously inflammable, keeps quality, and can be stored for a long period of time. For its high volatile matter content, brown coal is spontaneously inflammable and its heating value decreases during the storage. Without compacting, it cannot be stored for a long time. Mixtures of various (hard and brown) coal types cannot be stored, because they are highly inflammable spontaneously.

6) For the separate storage of the coals of different quality, two areas have to be considered:

   a) The current active and passive coal stockyards of the Power Plant where about 260,000-300,000 m^3 of coal can be stored

   b) The current auxiliary coal storage area of the grader, situated outside the Power Plant's premise, between the rail track and the road to the grading plant, where 150,000-180,000 m^3 of coal can be stored.

7) The particle size of the coal suitable for the boiler is 0 - 20 mm. For Borsod coals, this size is attained in the grading plant, but imported coal must be received with such size.

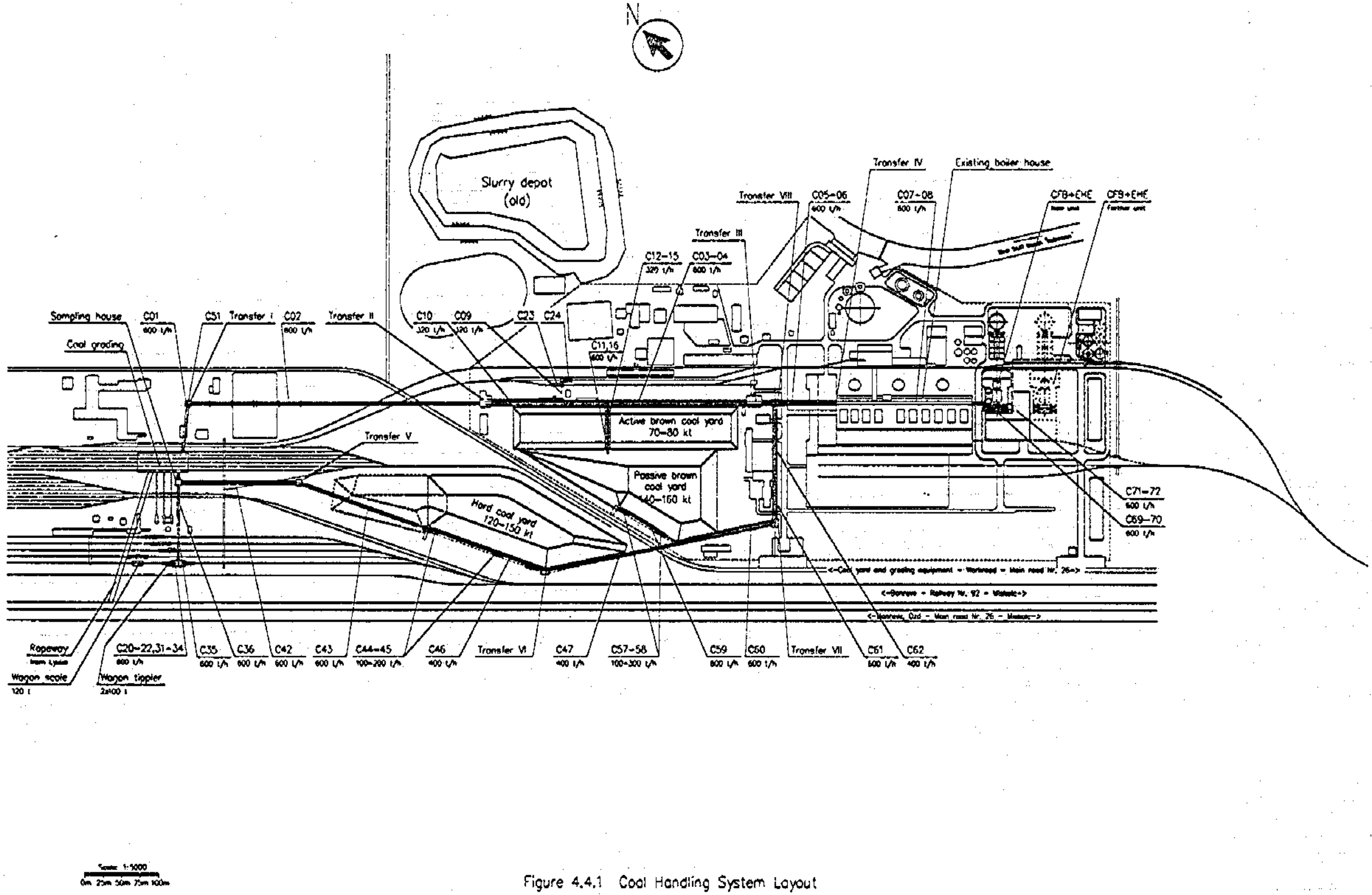
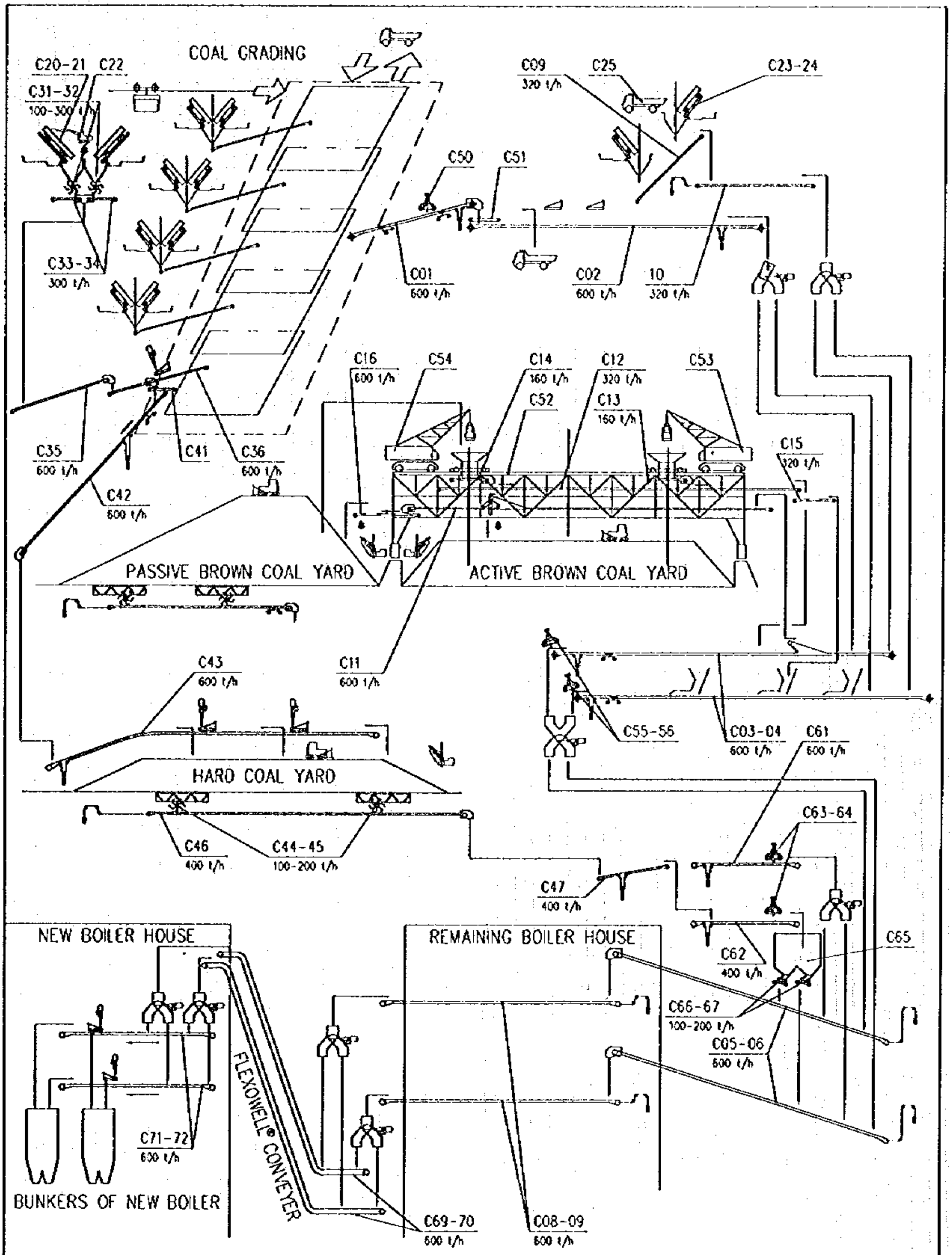


Figure 4.4.1 Coal Handling System Layout



SIGNS AND ABBREVIATIONS USED:

- Belt weigher
- Magnetic separator
- Rotary scraper
- Discharge plow
- Dust spraying
- Sprinkling

Figure 4.4.2 Coal Handling System Flow

8) For the reception, during the summer months, of the imported coal to the full capacity of the stockyard, necessary railway reception capacity is 2,000 - 2,500 t/d. Assuming a discharge time of 12 hours with 75% transporting efficiency, this requires a minimum of 320 t/h discharging capacity.

(3) Reception of Coal

1) The Power Plant receives the coal basically by conveyor belt from the coal grading plant, although direct railway reception and even road truck delivery through the grabbing bridge storage - pickup system are also possible.

2) The railway receiving system of the grading plant consists of five 2 x 50 tons capacity twin front tippers which are partly in proper working condition, partly renewable. One tripper can handle six of the 29 tons wagons per hour. Therefore, the necessary capacity is already available with two wagon tippers; 29 t x 6 x 2 = 348 t/h

3) Receiving wagons that can behandled by the existing front trippers are limited, and facilities for receiving 4-axle wagons used for international cargo transport are necessary. Consequently, 2 x 50 tons wagon trippers of No. VI positioned on the track No. V must be replaced with 2 x 50 tons wagon trippers.

(4) Environmental Protection

1) Coal dust produced through the coal transport: local hose filter ventilating system
2) Coal dust scattering in outdoor coal transfer areas: sprinkle system
3) Coal dust arising during coal handling: pile surfaces are sprinkled with water.
4) Drain containing coal dust: drainage ditch system and sedimentation ponds

4.4.2 Natural Gas and Fuel Oil Supply System

(1) Natural Gas Supply System

The rated capacity of the existing gas supply system is 15,000 Nm^3/h. This is insufficient to cover the increased demand. Therefore, two more gas receiving stations of the capacity equal to that of the existing one will be established. Thus, the total capacity of the expanded system will be 45,000 Nm^3/h, sufficient to operate the new unit at its rated capacity purely with natural gas firing. In this case, the gas demand will be about 41,000 Nm^3/h.

In addition to the boiler, the limestone drying equipment also requires a small quantity of natural gas.

(2) Fuel Oil Supply System

For the purpose of supplying oil to the ignition burners (unit capacity equal to 15% of MCR) and to the oil burners (unit capacity equal to 30% of MCR) of the new boiler during gas supply shortage periods, as well as to ensure the oil supply to the existing boilers, two oil reservoirs of 2,000 m^3 and 1,000 m^3 capacity, respectively, sufficient to cover 5 days of operation will be established.

4.5 Limestone Handling System

(1) Main System parameters

Reserve quantity	:	3 days
Consumption	:	18.4 t/h (Ca/S = 3)
Grain size	:	0~3 mm
Daily consumption	:	442 t/d
Daily receiving quantity	:	619 t/d
Receiving hours	:	7.5 h/d, 5 days /week
Storage capacity	:	3,000 t, (for 6.8 days)
Storage silo	:	Raw limestone: 1,300 m^3 x 1
		Limestone grist: 1,700 m^3 x 1
Bulk density of raw limestone	:	1~1.2 t/m^3
Grain size of raw limestone	:	0~50 mm

(2) Location of the Limestone System

Layout of limestone system is shown in Figure 4.5.1. The limestone system will be installed close to the south-east of Borsod Power Plant, or on the south-east from the railway No. I/a. Land procurement of 0.3 ha is necessary as a site added for the buildings of the limestone system.

(3) Reception and Storage of Limestone

1) Reception of limestone

The raw limestone will be transported to the plant by closed wagons. With 5 days' supply a week, the quantity to be received each day will be 442 t/d x 7/5 = 619 t/d. The time necessary for unloading the desired daily quantity of limestone will be approximately 7.5 hours.

2) Storage of limestone

It is necessary to secure a sufficient amount of limestone grist for stable operation of the Plant. Therefore, at least 1,325 tons of limestone grist will be stored. Supposing raw limestone is received on five working days a week, storage of at least 2-days load is necessary. That is, 1,210 tons of raw limestone with a grain size of 0-50 mm will be stored.

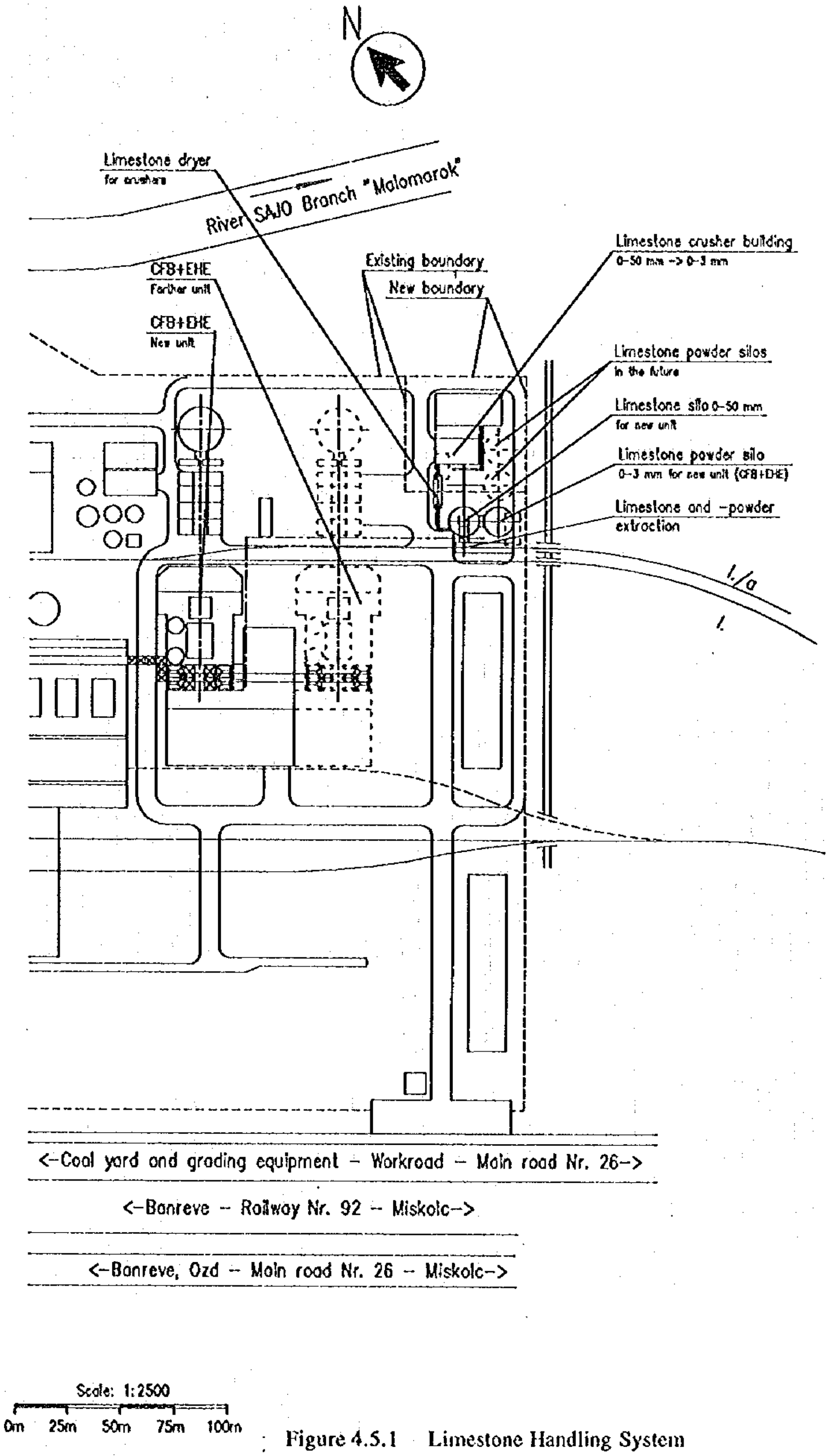


Figure 4.5.1 Limestone Handling System

In addition, the occurrence of any trouble in the grinding system should be taken into account. Thus, limestone necessary at least for 3-day operation will be stored.

Raw limestone and limestone grist will be stored in the silos of reinforced concrete (RC) in a closed system, with a capacity of 1,300 m3 and 1,700 m3, respectively, securing the amount necessary for 6.8-day operation.

(4) Outline of Limestone System

Block diagram of limestone supply system is shown in Figure 4.5.2.

1) Receiving the raw limestone

The drop-bottom type wagons will be unloaded on the discharge grate installed on the unloading track No. 1 built next to the plant railway siding No. I/a.

2) Production of limestone grist

The raw limestone of grain size 0 to 50 mm is ground to the limestone grist of grain size 0 to 3 mm. Considering that the raw limestone may contain humidity exceeding as much as 10%, drying is required for the subsequent pneumatic transport of the grist. A rotary drier is envisaged, in which the grist is dried by means of the cleaned flue gas obtained from the electric precipitator of the new boiler. The flue gas fed into the dryer will be recirculated through a dust separator cyclone and a flue gas booster fan to the inlet of the electric precipitator.

With two-shift work during 5 days a week at 75% operating efficiency, the necessary crusher capacity is 619 /(0.75 x 16) = 51.6 tons/hour, which can be ensured by using one hammer crusher.

3) Transport to the daily bin of the boiler

The crush limestone is transported to the daily bins in the boiler house by the pneumatic loosening system.

4) Facilities for receiving limestone grist from external sources

Considering the possibility of failure of the drier, facilities for receiving limestone grist from external suppliers are also provided.

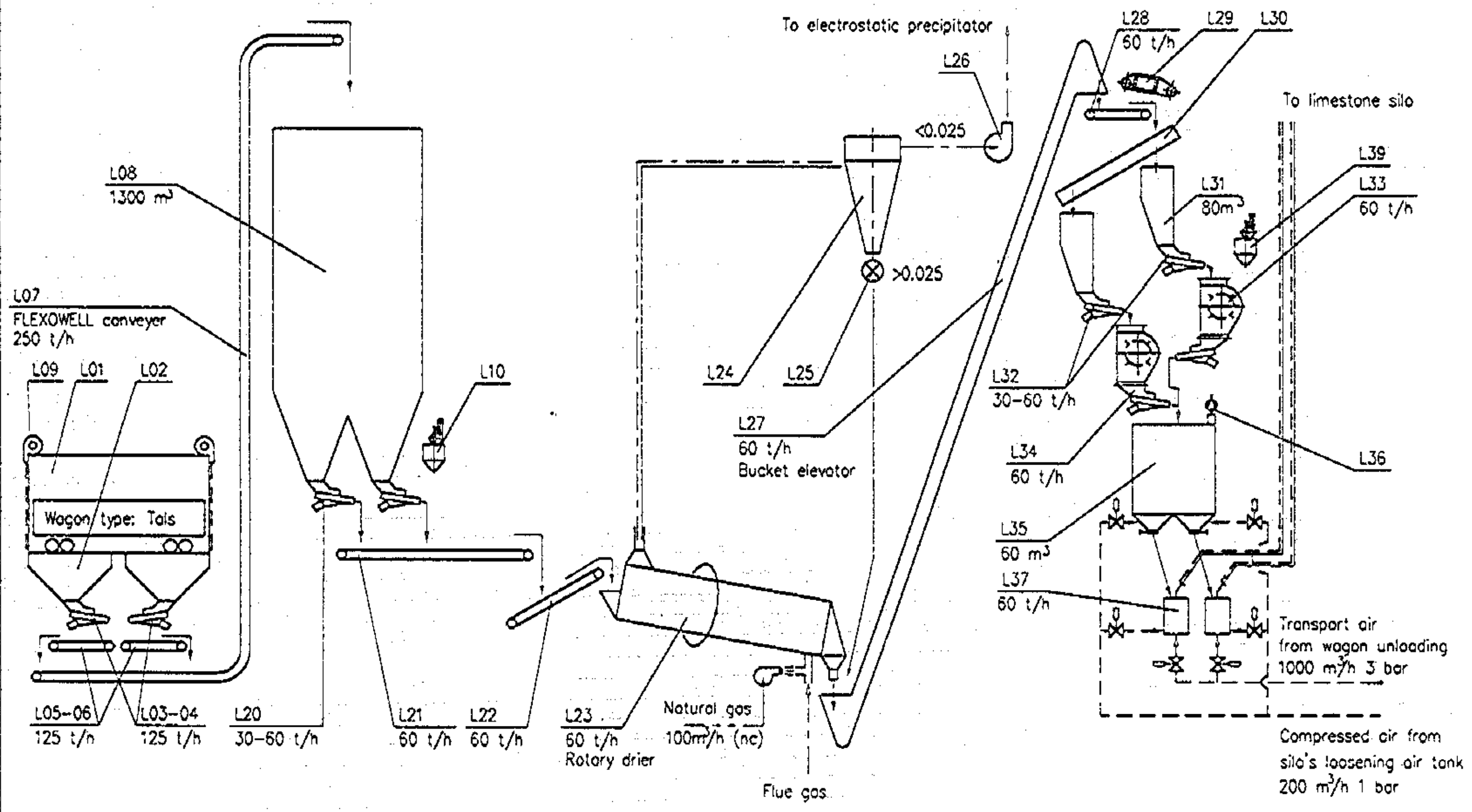


Figure 4.5.2 Limestone Handling System Flow

New Unit: CFB+EHE
Existing Units: Oil–Gas

(5) Environmental Protection

The interrelated process units with the limestone handling are of a closed design as follows:

a) Building for receiving raw limestone: pressurized air curtain and bag filter
b) Transport by conveyors: closed, using bag filters
c) Transportation of limestone grist: completely sealed system by pneumatic transport
d) Venting of storage bunkers: bag filters

4.6 Slag and Fly Ash Handling System

(1) Outline of System

1) Components of firing residue

With limestone addition, calcium sulfate ($CaSO_4$), calcium sulfite ($CaSO_3$) and calcium oxide (CaO) are contained in the firing residue from the CFB boiler.

2) Quantity of firing residues

The quantity of firing residues produced in the CFB boiler with mixed coal combustion is approximately 44.2 t/h.

(2) Collection of Bed Ash and Fly Ash from CFB Boiler

Ash is removed from the fluidized bed through the bed ash separator. The fly ash separated from the flue gas can be removed from the hoppers of both the EP and ECO, and transported to the slurry center through the pneumatic transfer system.

(3) Slag and Fly Ash Storage Area

The Power Plant has an existing slurry area.. The operation of the existing slurry area is supervised by the North Hungary Environmental Protection Inspectorate (ÉKF) and the North Hangary Water Management Authority .

a) The present authorized storage areas are the blocks Nos. V/1, V/2 and VII/2. Overall surface area of the blocks is about 55 ha with a capacity of approximately 5,000,000 m^3.

b) To use blocks VIII/1 and VIII/2 as new deposits, a preliminary permit was obtained from the Water Management Authority, but the volume of water allowed to permeate into the subsoil from each of blocks VIII/1 and VIII/2 is limited to 10 m^3/day. Their total area is 342,000 m^2

c) Considering the present (1997) state of filling and the unused sludge storage areas, deposition of the firing residue from the CFB boiler is ensured for about another 25 years.

4.7 Transformers and Others

(1) Transformers

The main transformer connected to the generator unit feeds the 120 kV network. The auxiliary transformer supplies electricity to all auxiliary units in the plant. Starting transformer ensures the start of the unit in the case of 120 kV network failure (abnormal condition).

(2) Auxiliary Switching Equipment

The total power requirement of the auxiliary unit amounts to 13 to 15 MW, distributed in either 6 kV or 0.4 kV voltages. Auxiliary switching equipment is as follows.

- 6-kV switching equipment
- 0.4 kV equipment
- 0.4 kV distribution system
- Diesel generator
- DC system

(3) Protective Measures

Protection of the unit shall be implemented in conformity with the relevant Hungarian standards and shall cover the following functions:

- Full protection of generator, covering the important components and the mode of operation.
- Full protection of the transformers (unit transformers, auxiliary unit transformers, starting transformers).
- Protection of bus bars at generator voltage.

(4) Voltages Applied

Network voltage:	120 kV
Generator voltage:	15.75 kV
Main switch gear of auxiliary service:	6 kV
Auxiliary service voltage of existing Power Plant:	3 kV
Starting transformer connection voltage:	35 kV
General auxiliary voltage:	0.4 kV
DC auxiliary service:	220 V and 24 V

4.8 Fresh Water Supply and Treatment System

4.8.1 Fresh Water Supply System

(1) Basic Water Demand Design Parameters

1) Waters taken at Malomárok of Sajó River

Untreated water (Q = 1114-1464 m^3/h) for the purpose of cooling water for steam turbines, etc.

Treated water (Q = 750 m^3/h) for the purpose of
- Bearing cooling water total
- Bearing cooling water of the new unit
- Make-up water of wet cooling system
- Utility water for water treatment plant

2) Water from Bódva River

Treated water (Q = 530 m^3/h) for the purpose of
- Demineralized boiler feedwater
- Demineralized water
- Ion free water
- Utility water for water treatment plant

3) Water discharged at Malomárok of Sajó River (Q = 1237-1587 m^3/h)
- Cooling water for steam turbines
- Drum filter flushing water
- Bearing cooling water, etc.

(2) Rehabilitation of the Intake Facilities

(a) Replacement of lift pumps	3 pcs.
(b) Renewal of settling basins	5 basins
(c) Renewal of drum filters	2 pcs.
(d) New cooling water pumps for steam turbines	6 pcs.
(e) New warming-up pumps of auxiliary cooling system	2 pcs.
(f) Pipelines (ϕ 200 ~ 400 mm)	l = 2,500 m

(3) Description of Water Supply System

1) The demand of the Power Plant for make-up water is met by taking water from Sajó and Bódva river.

2) The required quantity of auxiliary cooling water is maximum 2300 m^3/h and it is taken from the river Sajó.

3) Cooling water is taken from the river Sajó. Three pumps with vertical shaft delivers water to the settling basins. Water is pumped to the auxiliary cooling system of the turbo-generator unit through a long pipeline installed in concrete trenches.

4.8.2 Water Treatment System

(1) Basic Design Parameters

1) Demand of demineralized water

The demand of demineralized water for the new 150 MW unit and the existing 100 t/h boilers of the Power Plant will be 500 t/h.

2) Demand of softened water for cooling purposes: 630 t/h

3) Water quality data

(a) Bódva water quality

Conductivity	(μS/cm)	544.6
$KMnO_4$ consumption	(mg/l)	12.16

Average total mineral content of softened water produced from Bódva River:

	(me/l)	4.20

(b) Sajó water quality

Conductivity	(μS/cm)	564.6
$KMnO_4$ consumption	(mg/l)	9.77

4) Cooling water quality requirements

Water quality to be maintained in the cooling water system are as follows;

pH		> 6.5
free CO2	(mg/dm^3)	< 3

Carb. hardness	(me/dm^3)	1.4-4.4
Total hardness	(me/dm^3)	< 25
Mineral content	(mg/dm^3)	< 3000
Chloride content	(mg/dm^3)	< 1000
SO_4 content	(mg/dm^3)	< 300
Iron content	(mg/dm^3)	< 1
Suspended solids	(mg/dm^3)	< 20
SiO_2	(mg/dm^3)	< 100
Ammonia	(mg/dm^3)	< 1

5) Boiler water quality requirements (with regard to the new unit)

Steam parameters:	p = 164 bar
	t = 540 °C
Max. steam generating:	460 t/h

(a) Feed water

pH at 25 °C, min.		> 8.5
pH at 25 °C, max.		< 9.5
Dissolved oxygen, max.	(mg/kg)	< 0.01
Total hardness, max.	(me/kg)	< 0.001
Total iron content, max.	(mg/kg)	< 0.02
Total copper content, max.	(mg/kg)	< 0
Oil + suspended solids		0

(b) Boiler water

pH at 25 °C, min.		> 8.5
pH at 25 °C, max.		< 9.7
SiO_2 content	(mg/kg)	< 0.35
p-value	(me/kg)	< 0.05
Conductivity (25 °C, after neutralisation)	(mS/m)	< 4.00
PO_4 content	(mg/kg)	< 6.00
$KMnO_4$ consumption	(mg/kg)	< 5.00

(2) Demineralisation System

The existing demineralisation system does not need to be modified.

(3) Necessary Changes in the Cooling Water Softening System

Breakdown of cooling water demand:

507 t/h to cooling tower	H=10 m pressure
123 t/h to bearing cooling	H=75 m pressure

1) Raw water supply will be arranged from the existing settling basins from the River Sajó.

2) The capacity of the existing small reactor (ϕ 7600 mm) shall be increased to Q=250 t/h. One new reactor will be installed (ϕ 13 000 mm) with a capacity of Q=500 t/h.

3) 3 pcs new filters (capacity = 80 t/h, ϕ 3,150x3,000 mm) are added to serve the new 500 tons/h reactor.

4) For filter backwashing, 2 pcs of new filter washing pumps will be installed.

5) For the purpose of storing softened water supplied as cooling water, one new softened water tank has to be installed with a capacity of 500 m^3.

6) Pumps installed for supplying cooling water

   3 pcs cooling water pumps for the cooling tower
   2 pcs cooling water pumps for the bearings

7) In order to prevent corrosion, scaling and algal formation, conditioning agents will be added to the cooling water.

8) The saturated $FeSO_4$ solution is transferred from the existing storage tank to the dosing tank by a transfer pump.

9) For the new lime softener, 1 lime powder silo (220 m^3) and 1 lime powder metering tank will be installed.

10) 3 lime milk agitators (26 m^3) and 2 twin-piston dosing pump (lime milk - iron sulphate) will be installed.

(4) Wastewater Treatment and Utilisation

For the purpose of receiving and treating wastewater, a underground concrete basin with two parts (2x900 m^3), having a chemical-resistant coating, will be installed.

(5) System Layout

The tanks are to be installed in the open air near the filter house, valves will be located in the filter house.

4.9 Cooling System

(1) Basic Design Parameters

1) Cooling water demand (new steam turbine condenser) : 20,000 m^3/h

2) Auxiliary cooling water demand : 613 m^3/h

3) Design parameters for the cooling system:

Cooling water flow	20,613 m^3/h
Inlet temperature of hot water	40 °C
Outlet temperature of cold water	32 °C
Dry temperature of ambient air	30 °C
Wet temperature of ambient air	21 °C

(2) Specification of Cooling Equipment

1) Cooling tower

Floor area	4 pcs. x 18 m x 18 m
Height	12.5 m
Amount of make-up water	507 m^3/h

2) Circulating pump 3 pcs.

3) Blow - down pump 2 pcs.

(3) Operation of the Cooling System

1) The cooling system for the new unit is independent from the fresh water cooling of the other units. The closed system has a wet cooling tower. Cooling water is delivered by circulating pumps from the basin below the cooling tower to the main and auxiliary cooling system of the new unit.

2) The cooled water flows into the concrete basin located below the tower. The cooling water circulating pumps will transfer cooled water to the condenser.

3) In case of an ambient temperature below 0 °C, the pumping of the cooling water to the cooling tower may become unnecessary. Consequently, there is a possibility to circulate it through a bypass line within the basin.

4) The cooling performance is controlled by

- reducing the speed of the individual fans by 50 %
- stopping the fans individually
- isolating the individual cooling cells by closing the isolating valve of the cells
- making use of the by-pass line of the cooling system.

4.10 Architecture and Civil Works

(1) Design Conditions

The following conditions were studied to determine dimensions, shapes and structures of buildings and civil engineering installations:

- layout plan of equipment
- plan of transferring the materials
- system of access roads necessary for construction and maintenance
- layout of pipe and cable networks
- load conditions
- soil conditions
- adaptation to existing installations
- the official regulations and standards being in effect in Hungary
- implementation schedule

(2) Main Buildings

Main buildings are shown in Table 4.10.1.

Table 4.10.1 Main Buildings for the New 150 MW Unit

	Description	Pcs	Constr.	Width(m)	Length(m)	Height(m)	Note
Main Buildings	1. Boiler House	1	steel	31.00	47.00	54.00	partially enclosed
	2. Turbine building	1	steel	27.00	60.00	27.00	
	3. Control building	1	r.c.	24.00	30.00	15.00	
	4. Feedwater building	1	Steel and r.c	9.00	60.00	15.00	
Foundation	1. Turbo-generator suppporting frame	1	r.c.	11.50	30.00	9.70	
	2. Electr. precipitator	1	r.c.	24.00	32.00	1.50	
	3. Unit transformer	1	r.c.	4.50	8.00	3.00	
	4. Aux.unit transf.	2	r.c.	3.50	5.00	3.00	
	5. Flue gas duct	2	r.c.	3.00	6.00	1.50	
	6. Combustion air fan	2	r.c.	3.00	7.00	3.00	
	7. Flue gas fan	2	r.c.	5.00	10.00	3.00	
	8. Pipe bridge (fly ash)	50	r.c.	3.00	5.00	1.50	
	9. Pipe bridge (limestone)	20	r.c.	3.00	5.00	1.50	

1) Boiler house

The boiler house for the new 150 MW unit is to be placed at the SE side of the existing building.

Instead of a construction having floors covering the overall basic area, the boiler house for the out-door circulating fluidized bed boiler should be understood as a system of platforms and stairs for operation and for access to the pieces of equipment at different floors.

The boiler is to be covered by a light-weight metal construction roof, and heat-insulated sheet metal shell covers those parts necessary to meet weather-proof requirements of the equipment.

The overall axial dimensions of the boiler house are 31 m x 47 m. It has 12 floors, and the highest point is 54 m.

2) Turbine building (Machine hall)

The turbine building is 60 m long, 27 m wide, and 27.00 m high. The height of the reinforced concrete table for the turbo-generator is +9.70 m.

The load-carrying capacity of the bridge crane having a span of 24.50 m is 50 tons at the main hook and 15 tons at the auxiliary crab.

To ensure personal traffic between the new and the old machine houses, a cross-over bridge of about 18.00 m span for pedestrians is installed at elevation +9.70 m.

3) Central control building

Of the overall length of 60.0 m of the turbine building, the adjacent boiler house will cover a width of 31.0 m. The central control building of 24.0 wide is built at the remaining area. The length of the control building is 30.0 m.

4) Feed water building

The feed water building is 60.0 m long and 9.0 m wide.

On the ground floor, a crane runway is provided with a rail top height of +7.00 m for a 10 ton crane, which will be used to move transformers, pumps, etc.

On the uppermost slab of the elevation +15.00 m, the feedwater tank (150 m^3) with the deaerator is placed outdoors.

(3) Stack

1) Design considerations

The following conditions were examined to determine the specifications of the stack:

- flue gas flow rate
- flue gas velocity
- flue gas temperature
- stack height (130 m)
- emission limit values

The result is shown in Table 4.10.2.

2) Structure of stack

Flue gas is discharged through a reinforced concrete stack of 130 m height. The temperature of the flue gas will be about 150 °C, therefore, the inside of the stack is lined with refractory bricks at a depth of half brick.

Inner diameter of the lined stack	:	4.00 m
Min. thickness of the stack wall at top	:	0.20 m
Max. outer diameter of the stack at foot	:	8.00 m

(4) Related Facilities

1) Water supply and sewerage

The buildings are supplied with water for sanitary facilities (lavatories, showers and toilets) and room cleaning. Water and sewage pipes of the buildings can be connected to the respective existing network.

As a result of introduction of the new unit, the increase in drinking water demand is 7.5 m^3/d with hourly peak rate of 1.85 m^3/h. The methods of fitting water and swage pipes are conventional.

Table 4.10.2 Specification of Stack

Description	Meas. unit	Values	Note
Turbine output	MW	150.00	
Temperature	°C	150.00	
Flue gas volume-flow	1000 m^3/h (n.c.)	605	
	m^3/sec (n.c.)	168.06	
Qg =	m^3/sec	261.00	at actual gas temperature
Flue gas density	kg/m^3 (n.c.)	1.307	
rg=	kg/m^3	0.849	
Proposed stack dia.	m	4.00	internal, at top
Proposed stack section	m^2	28.26	internal, at top
Flue gas velocity	m/sec	9.20	at outlet
Flue duct cross-section	m^2	20.00	(4 x 5) m
Flue gas velocity	m/sec	13.00	at outlet
Intake at base	m^2	28.00	(4 m x 7 m)
Flue gas velocity	m/sec	9.30	at stack inlet
Air density	kg/m^3	1.185	at 25°C ambient temp.
Natural draft (Z)	mm W.G..	43.7	
Pressure loss (1)	mm W.G.	6.3	stack outlet loss
Pressure loss (2)	mm W.G.	4.3	stack friction loss
Pressure loss (3)	mm W.G.	2.2	stack in let loss
Total	mm W.G.	12.8	
Resulting draft	mm W.G.	31.6	

2) Central heating system

There is steam as heat transfer medium at disposal in the area.

Heating of the main building complex consisting of the boiler house, the turbine building, the feed water building, and the central control building is proposed to be provided according to the individual demands. The covered portions of the boiler unit requiring heating as well as the turbine building and the feed water building are provided with thermo-fan heating through steam-heated unit heaters.

3) Air conditioning, ventilation

The central control room is air-conditioned featuring the following parameters:

ti (winter)	:	+20°C
ti (summer)	:	+24°C
humidity	:	40%

The air conditioning appliances have hot water heating and freon-type cooling systems. There will be an over-pressured atmosphere in the rooms. Relative humidity will be maintained by means of a steam generator.

The removal of the heat released from the transformers, cables and the equipment in electricity-related rooms and air change are facilitated by the forced ventilation system.

4) Railway Siding Network and Roads

The railway network of the plant will be modified to fulfill the highest demand of transporting coal and limestone as follows. (Figure 4.10.1)

- The tail track No. I/a of 330 m length will be established starting with and 6.00 m away from the segment 7+80 of rail track No. I, with a shunt of system 48. The unloading building common for both the drop-bottom wagons and those with pneumatic discharge facility will be built along the segment 6+30 of the rail track.

- The rail tracks No. VII including the shunt No. I/10 laid in the existing old plant building will be removed in 400 m length.

A suitable new road network will be established within the Plant connected to the external service road as well as installation of a new gate. Since the rail track No. VII is removed, large size equipment will be transported to the existing and new main buildings through this road network.

(5) Fire Fighting

1) Fire fighting system

The amount of fire fighting water required for the main fire section is 6,000 l/min. Therefore 2 additional pumps each having the capacity of 3,500 l/min with 80 m head shall be added to the existing pumps. At the surface hydrant located farthest, an outlet pressure of 5 bar should be provided. At the wall hydrant located farthest and highest, an outlet pressure of min. 2 bar should be provided in compliance with the relevant Hungarian Standards.

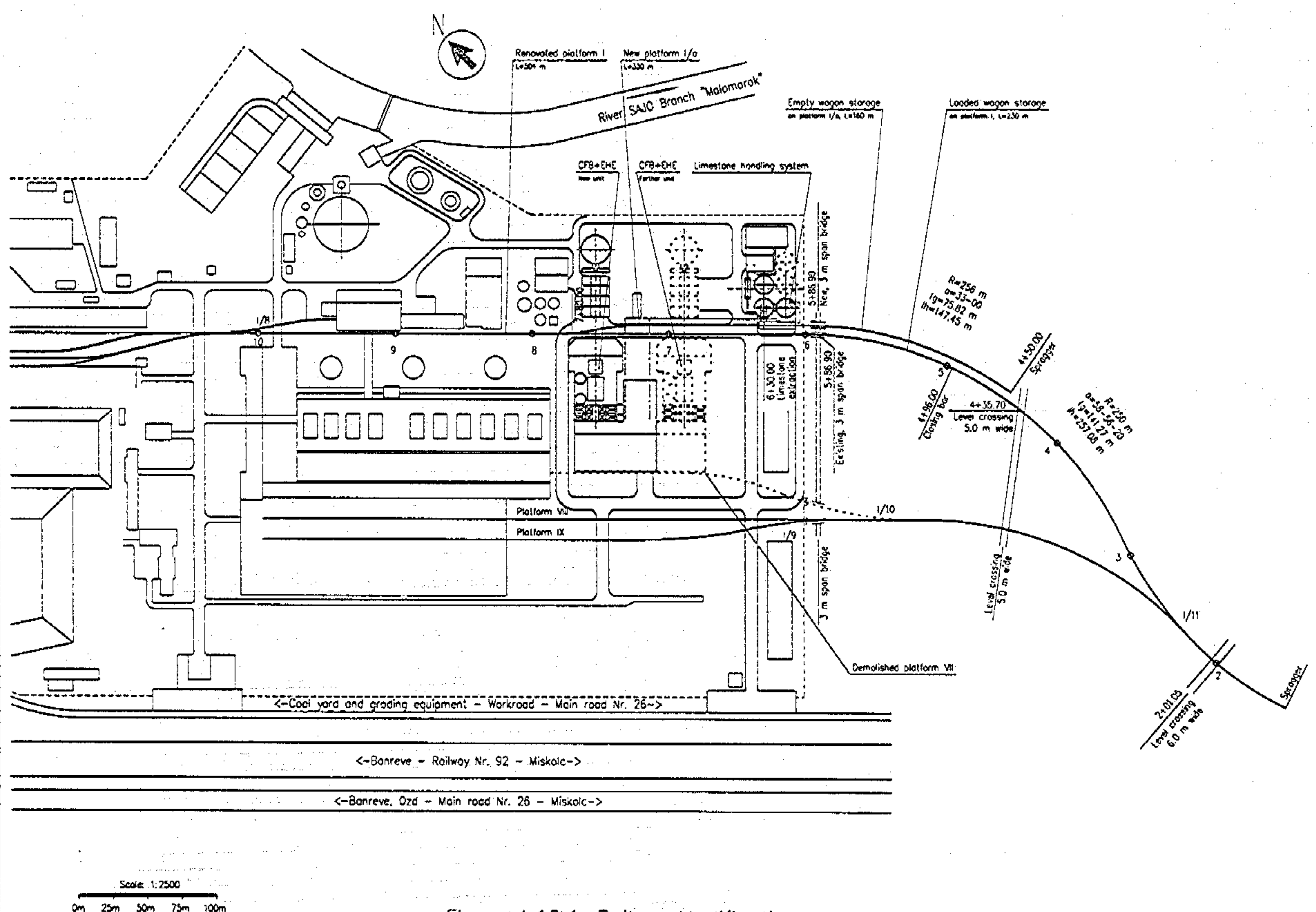


Figure 4.10.1 Railway Modification

Pumps are started automatically one after another by a network pressure monitoring system as required by varying consumption.

The special water system of the coalyard (to be used for watering coal and extinguishing fires in case of self ignition) will be branched off from the fire fighting water network (one feed point at both of the eastern and western side of the yard).

(2) Foam-Sprinkler System of Inclined Coal Conveyor

Fire protection shall be provided to two inclined belt conveyors of about 100 m length and 3 m width. The level difference of the conveyer is about 35 m.

Specific water flow	:	5 m^3/min
Protection area	:	144 m^2
Operation period	:	60 min, of which 10 min in foam mode
Max. spray area	:	10 m^2

(3) Fire alarm system

The existing old conventional system and its center should be integrated as a subsystem in the new fire alarm network. In the area of the new unit, each room, cable marshalling room, cable trench and dangerous technological equipment, etc. are protected by addressable sensors in order to send an early fire alarm if fire breaks out. The new intelligent fire alarm center is expedient to be located in the central control room. The fire alarm system to the professional fire brigade of the municipality should be established.

4.11 Control and Instrumentation

(1) Main Features

The unified control and instrumentation system of the 150 MW unit to be established within the Power Plant will be Distributed Control and Information System (DCIS). (DCIS system is shown in Figures 4.11.1 ~ 4.11.3) This system has hierarchical structure with distributed intelligence. The main features are as follows.

1) Both the closed loop and open loop control as well as the safety tasks common to the circulating fluidized bed fired boiler and the unit will be performed by the unified DCIS. The process-end equipment including those controlling the boiler, the electric equipment, feedwater + hot water + cooling water systems together with the devices interfacing the subsystems shall consist of general purpose devices designed for industrial use that are connected to the system bus.

2) The control and safety subsystems of steam turbine that requires extremely short response time and high reliability (e.g. speed control, load control, starting, turbine protection, heat load analyzer) are built with process control hardware components of high reliability and specially designed for use in Power Plants.

3) The unit is provided with an unified process control subsystem of which components are connected together via high-speed links (system bus).

4) Operation of such subsystems as water treatment, coal and limestone handling etc. need to be controlled in places other than the unit control room for technological reasons. The data acquired from these subsystems are transferred to DCIS.

Outlines of process control equipment, measuring circuits, control structures, and power sources that constitute DCIS are given below.

(2) Process Control Equipment

The equipment shall show the reliability indices as follows.

(a) The MTBF (Mean Time Between Failures) that basically determines the reliability shall be at least 16,000 hours for each unit built with CPU and 40,000 hours for equipment required to be of high availability.

(b) The diagnostic feature and mechanical design of product shall ensure that the MTTR (Mean Time to Repair) shall not exceed 2 hours.

(c) The allowed average storage time of spare parts of products shall be at least 10 years.

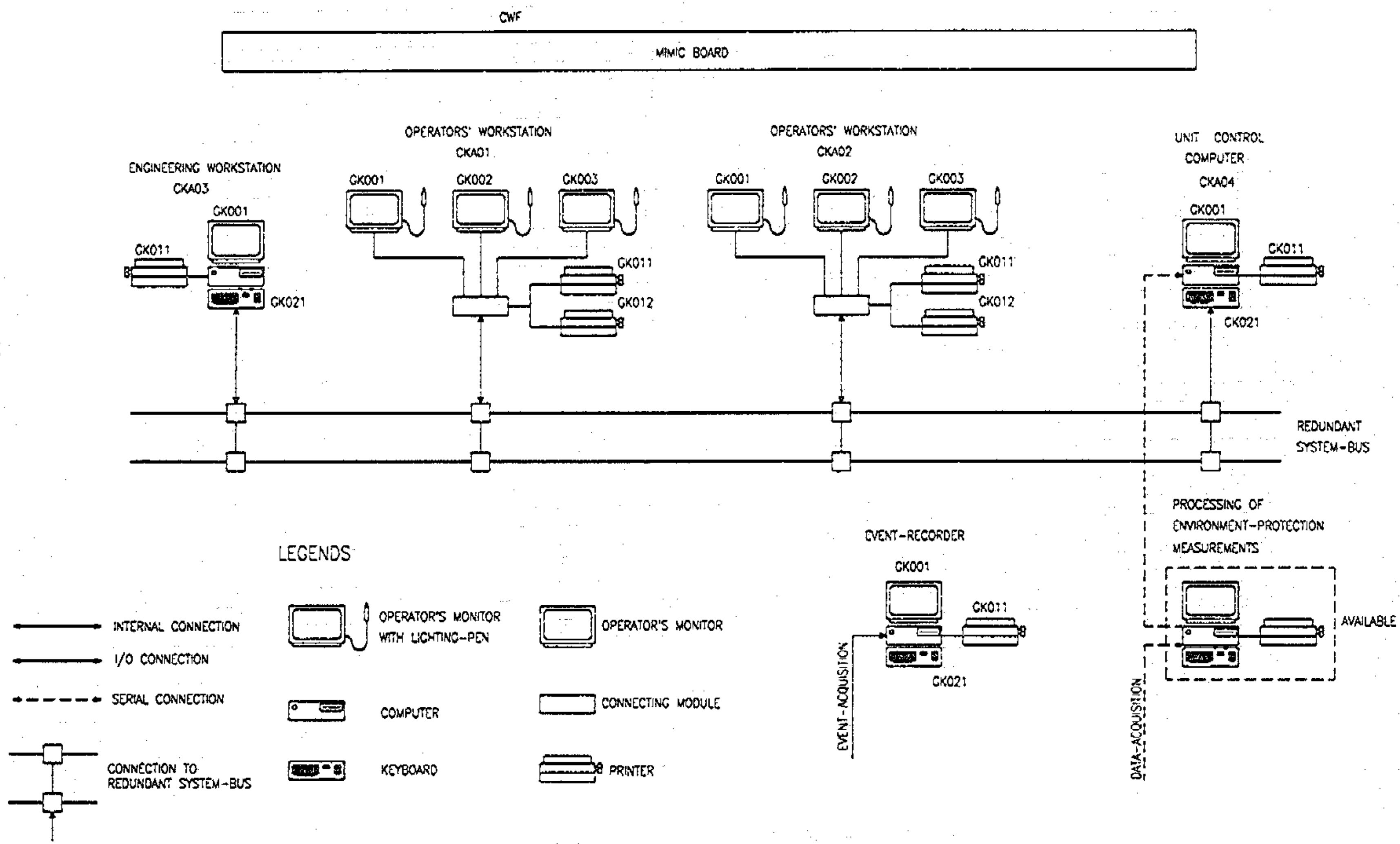


Figure 4.11.1 DCSI System (1/3)

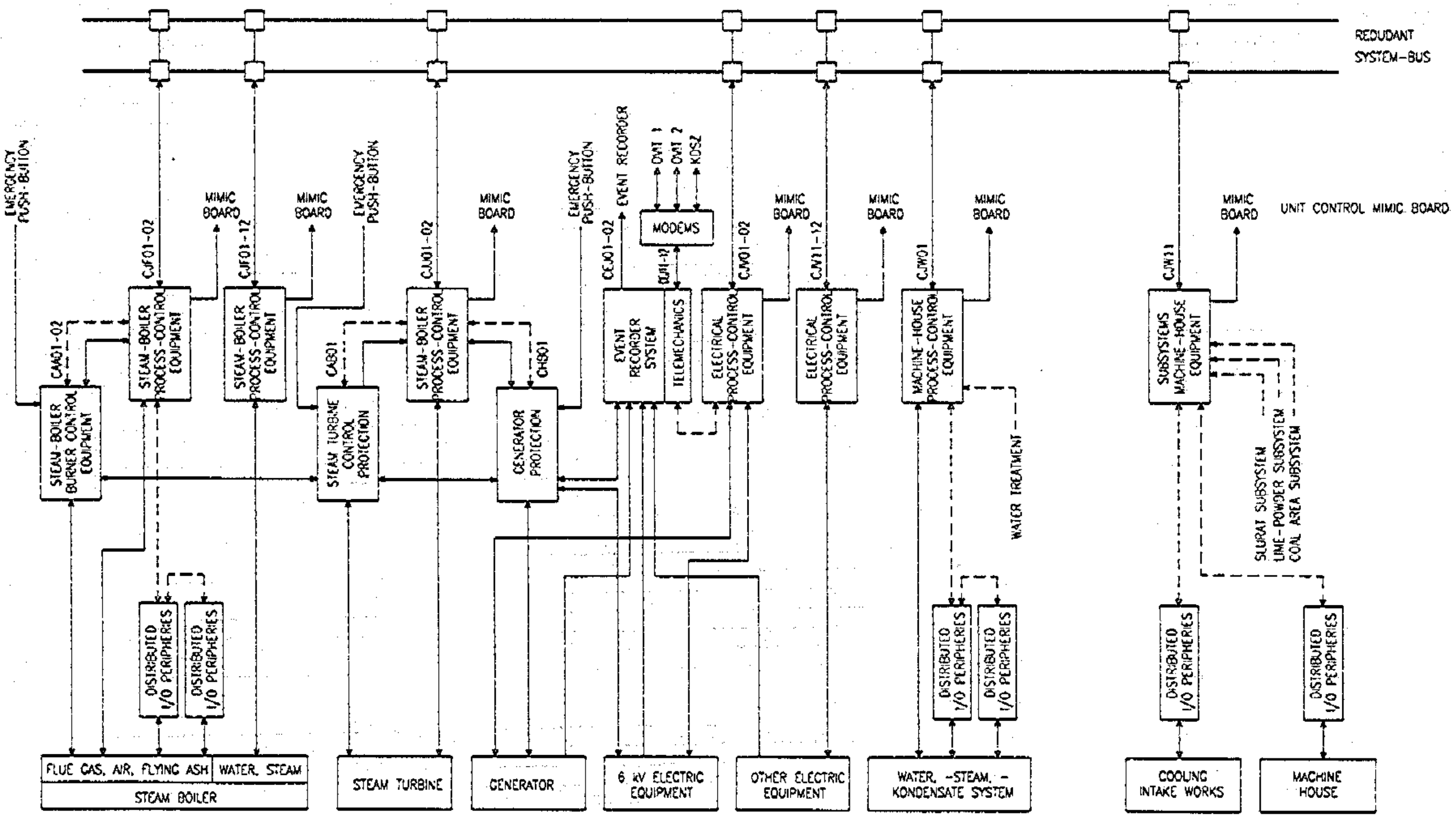


Figure 4.11.2 DCSI System (2/3)

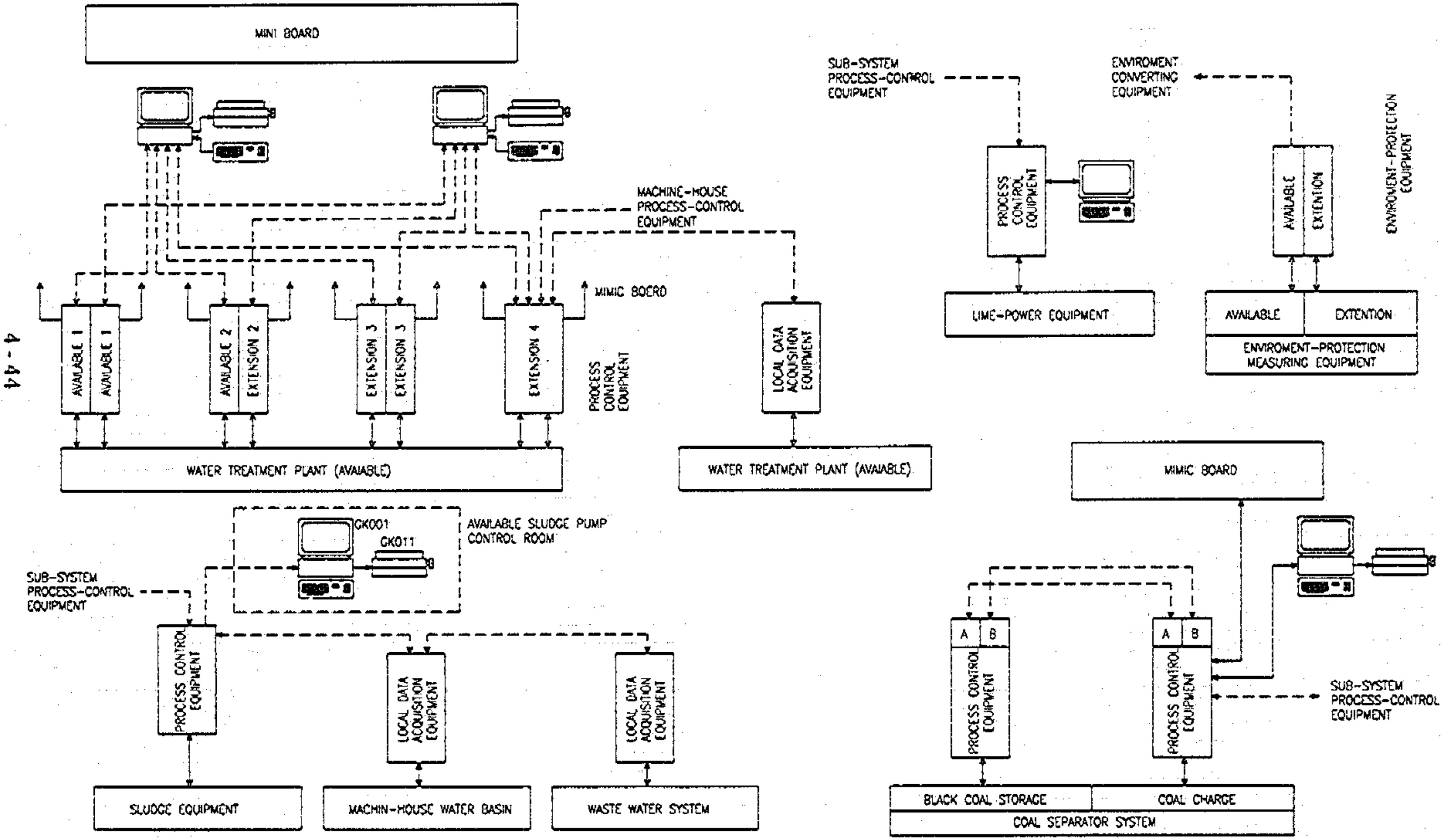


Figure 4.11.3 DCSI system (3/3)

(d) The average service life of control and instrumentation devices that represents their durability shall be at least 15 years.

(3) Measuring Circuits

1) The measuring circuits necessary for the process control tasks use transmitters of 4 to 20 mA output signal range in two-wire system.

2) The indicating instruments mounted in the annunciation boards shall be provided with digital display with minimum and maximum limit indication in the case of vital parameters (e.g. Hz, MW), while those indicating the other parameters shall be of analogue design.

(4) Control Structures

Signal processing is always be performed by the processor nearest both to the signal source and the destination of the signal already processed, using the shortest possible signal path. The manual control of manual/automatic mode, set point, actuating signal can be performed from the operator console. The operator is not allowed to perform any alteration on the control structure and settings. Actions of this kind are reserved for software maintenance personnel authorized for accessing higher level of hierarchy, namely primary engineer's workstations.

(5) Power Sources

The power supply voltages to the process control system are 3-phase 380/220 V AC 50 Hz and 24 V DC. The 24 V DC power supply is based on two battery sets, provided with rechargers and appropriate filters. Basically, the DCIS is powered by 24 V DC, but it is permanently connected through diodes to both battery sets. Equipment that shall be operated without interrupt and require 220 V 50 Hz power supply, will be powered from UPC (uninterrupted power supply) of appropriate capacity. Equipment not required to be operated without interrupt will be powered from 380/220 V network.

4.12 Grid Connection

The connection voltage level of the new 150 MW unit, considering the unit capacity and the existing 120 kV switching equipment of the power plant, shall be 120 kV. The starting transformer is connected to the 35 kV network in case of no voltage on 120 kV at the time of unit start.

(1) Source and Consumer Data

1) Source data

Power to be transmitted to the 120 kV network from the new 150 MW unit and existing facilities is 161 MW in winter and 155 MW in summer. The operational power output distribution is shown in Figures 4.12.2 and 4.12.3.

Connection of the new unit to the 35 kV network shall be through field No. 22 and 32. (Figure 4.12.1)

2) Consumer data

It is expected that the demand on the 35 kV bus-bar of Borsod power plant by the BVK will be 22-23 MW and the demand by ÉMÁSZ will be 20-22 MW (altogether 42-45 MW) in 1997. The above demands are practically identical during the winter peak load period and during the summer minimum load period because of the character of 35 kV consumers. For calculations, 42 MW is used as consumer demand.

(2) Connection of the New Unit to the 120 MW Network

Power output distribution on the transmission of 161 MW (in winter) and 155 MW (in summer) output, which is fed to the 120 kV network in the Borsod power plant has been examined. The power output distribution calculations are prepared on the basis of the internationally approved (n-1) principle. The result of the calculations are as follows.

1) According to the result of the network analysis of 150 MW unit, the above power transmission lines are capable of transmitting the output of the new 150 MW unit and the existing units without overload under both normal operational condition and operational disturbances. Therefore, modification of the existing 120 kV network is not required. The location of the new unit is appropriate in the view point of the relation between 120 kV network voltage and the reactive power.

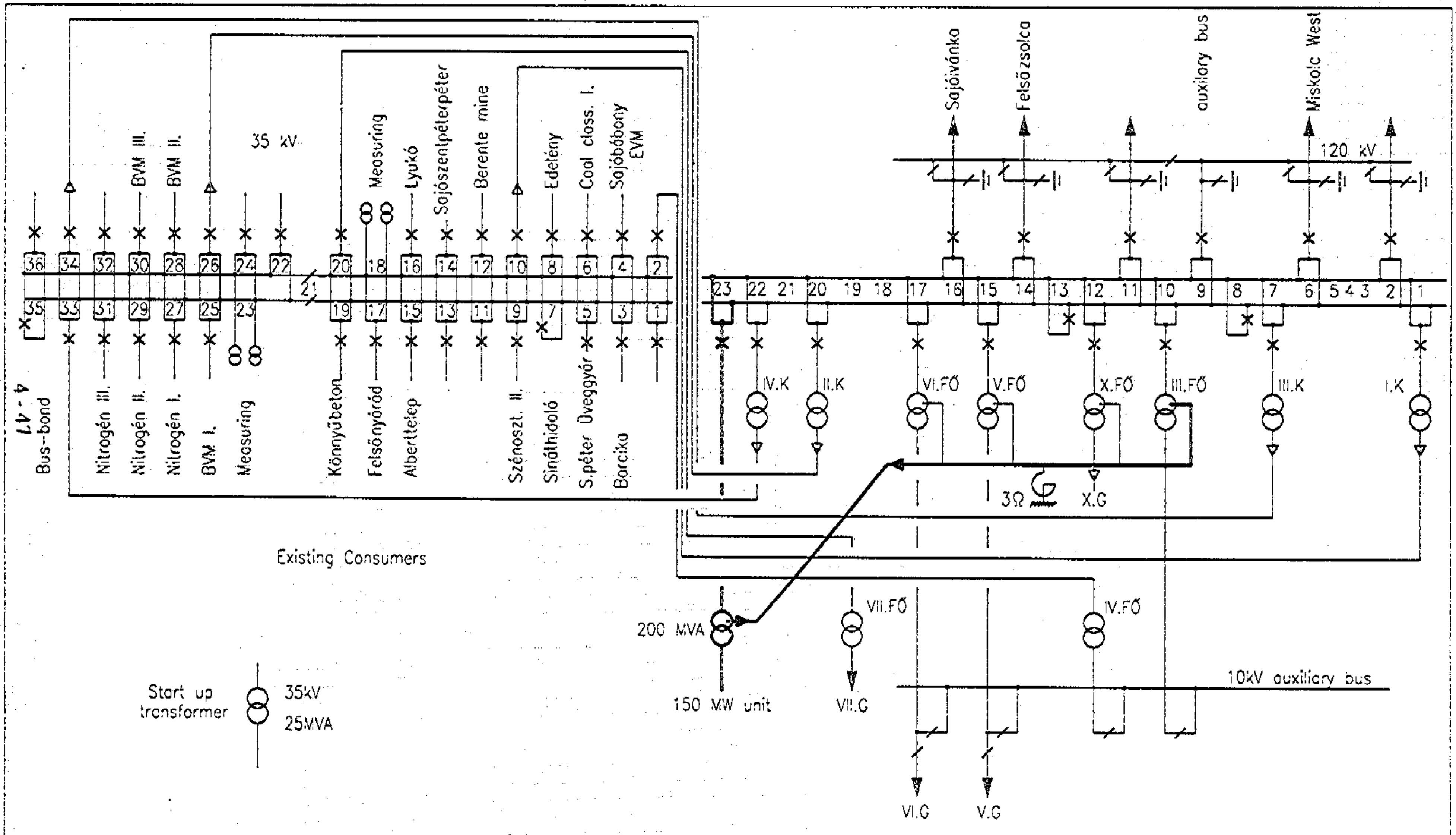


Figure 4.12.1 Single Line Connection Diagram

WINTER

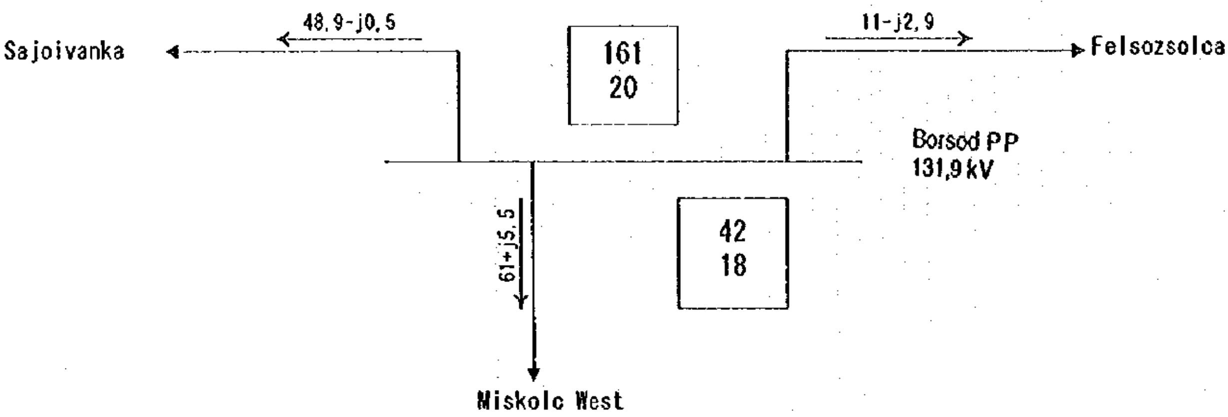


Figure 4.12.2 120 kV Bus-Bar Operation in Winter

SUMMER

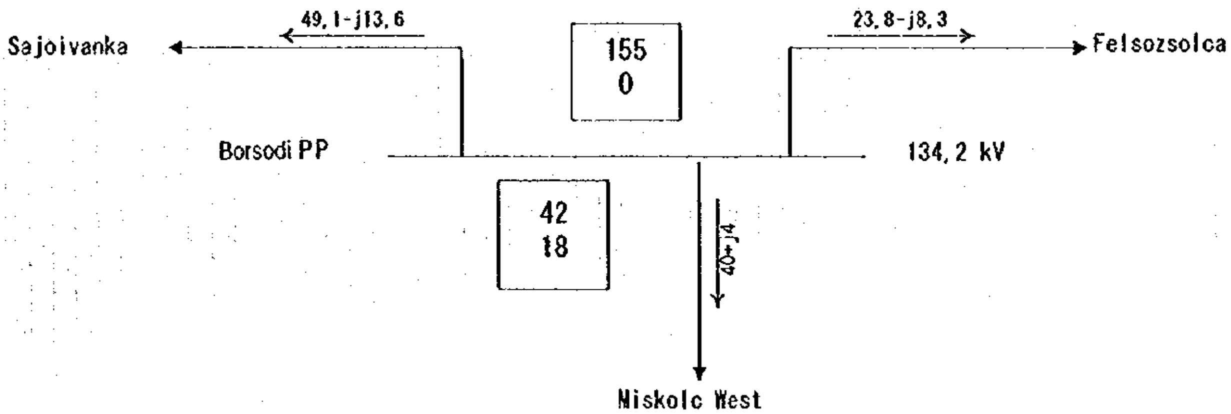


Figure 4.12.3 120 kV Bus-Bar Operation in Summer

2) The unit can be connected to the 120 kV field No. 23 and the connection can be implemented through the bus-bar for 1000 A and of 640 mm^2.

3) On the basis of the short circuit fault calculations the star point of the unit transformers of the new unit is recommended to be earthed through the existing 3.03 ohm choke.

4) The new unit shall comply with the requirements of the UCPTE connection with regard to primary control, reserve power output maintaining and voltage-reactive power control.

Chapter 5

Preliminary Design for Renovation of Existing Facilities

Chapter 5 Preliminary Design for Renovation of Existing Facilities

5.1 Boilers and Firing Equipment

(1) Reconstruction of Boilers

Side views of the existing boilers of two types after reconstruction are shown in Figures 5.1.1 and 5.1.2.

1) Membrane wall at bottom of combustion chamber

The original bottom of the boiler is cut off at 10,000 mm from the ground level to remove the membrane wall below, and all equipment for bottom-ash removal is also removed. A new membrane construction is welded air tight to the vertical parts of the remaining walls. This solution also ensures the proper location of two pieces of gas/oil burners, while providing excellent access for the operators to the burners.

2) EGR duct

Exhaust gas recirculation (EGR) ducts will be connected to the ash discharge funnels of the existing economizers (ECO) in the second pass. The ducts running through draft EGR fans will be divided into two and connected to the both sides of each boiler bottom.

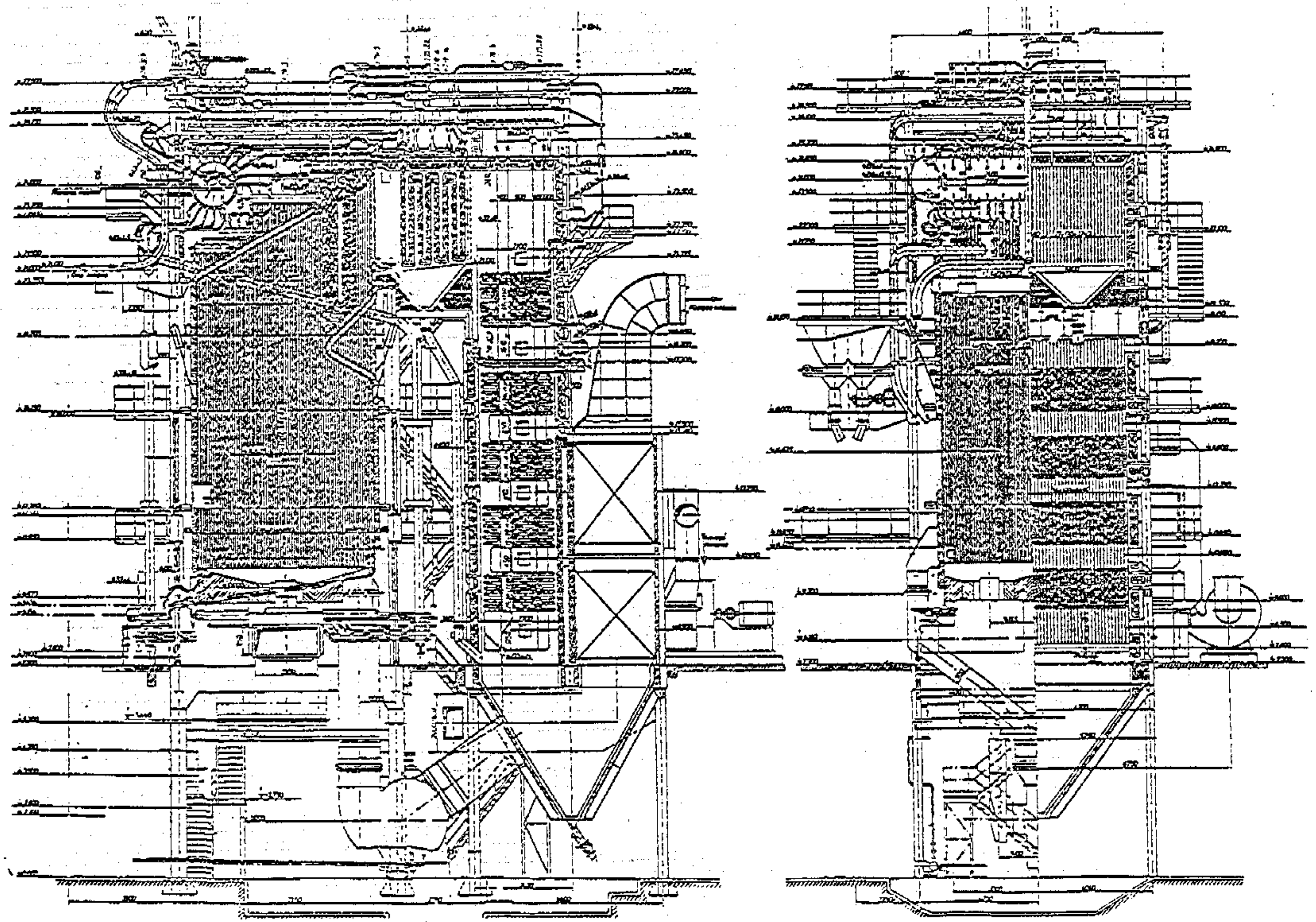
(2) Burners

1) Heat input of burners

The maximum heat input of two natural gas / fuel-oil burners is designed to be 90MWth.

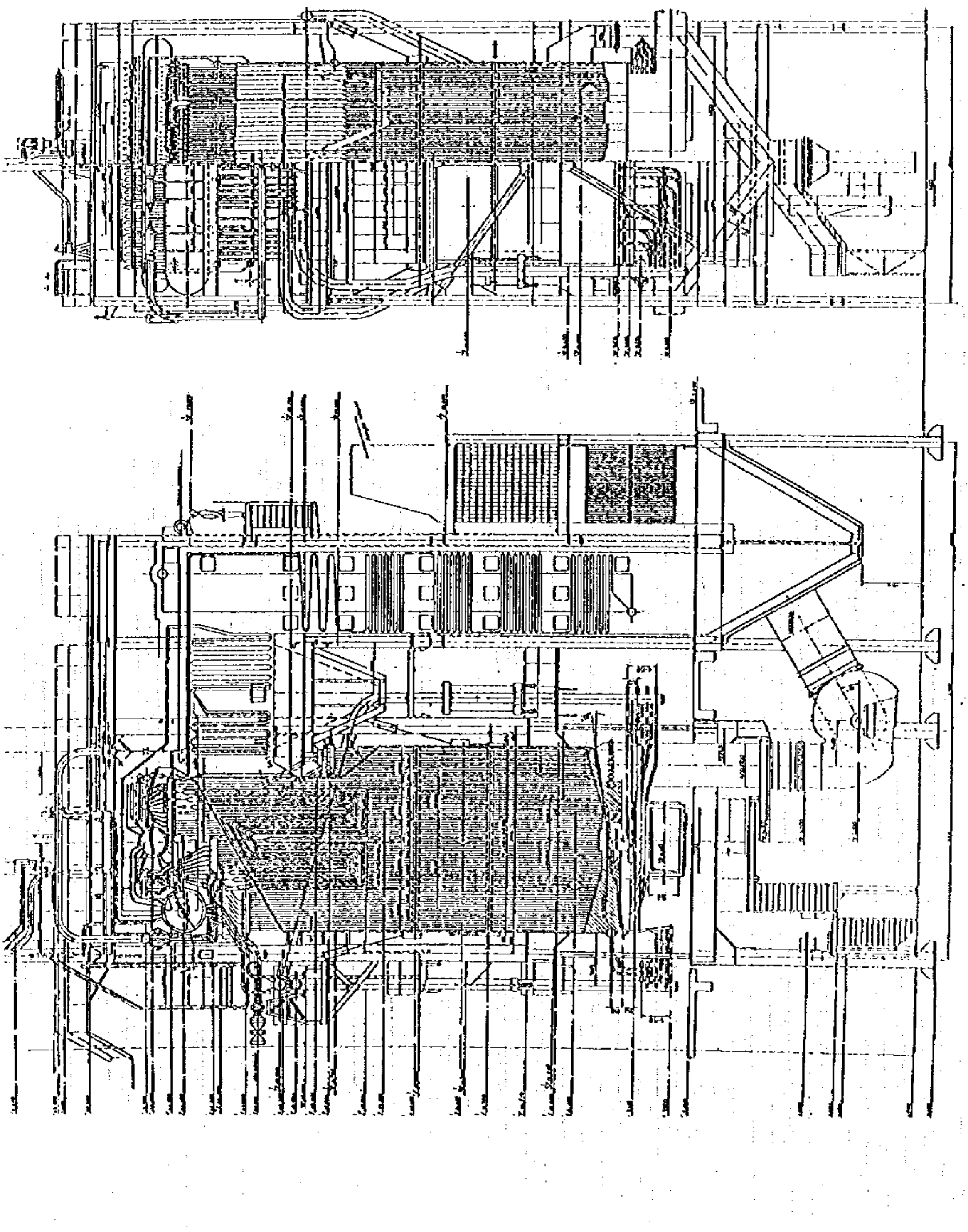
2) Emission level by the low-NOx burners

The discharge of pollutants is drastically reduced by fuel change and boiler reconstruction, compared to that of the present coal combustion. On each burner maker, guaranteed concentrations of pollutants are indicated. These values satisfy the emission standards applicable from 2004. Low-NOx technology adopted in these burners is exhaust gas self-recirculation. The NOx concentrations when using gas and fuel oil are 120 - 200 mg/Nm^3 and 120 - 240 mg/Nm^3, respectively.



Prepared by : GEA/EGI Rt. & TRE/Ganz-Röck Rt. Consortium

Figure 5.1.1 Lateral view of 100-M boiler after fuel conversion



Prepared by : GEAVEGI Rt. & TRE Ganz-Rolox Rt. Consortium

Supposing the sulfur content in the fuel oil is 0.2%, the concentration of SO_2 in the exhaust gas will be 252 mg/Nm^3.

(3) Combustion Air and Flue Gas System

1) Combustion air

Control of the fans will be done by the new frequency- converters and vane control system. The driving motors are also replaced.

2) Flue gas system

The design conditions for the induced draft fans (IDFs) for the renovated boilers are as follows: a static pressure difference of 30 mbar induces the exhaust gas of 60 m^3/s at a temperature of 165 ℃. However, due to the efficiency of existing IDFs lowered to 70-72%, the motor output should be increased by 39 - 35kW. Therefore, gears and frequency controllers are newly required. The efficiency of the new draft fans will be 81 - 82%.

3) EGR system

EGR system will be installed to control the temperature inside the furnaces when the boilers are subjected to low loads. The number of draft fan is one. The recirculation rate corresponding to the changes in the boiler load is controlled by changing the vane angles. The gas suction inlet for recirculating exhaust gas is attached to the hopper under the economizer, and the EGR duct is connected to the bottom of the side walls of the boiler.

4) Connection of stacks and boilers

The Hungarian regulations does not allow to discharge exhaust gases of coal firing boilers and gas firing boilers through the same stack. Therefore, it is necessary to connect boiler No. 7 to stack No. II in order to continue the operation of the boilers No. 5, 7, 9 and 10 in the future. Namely, the boilers No. 9 and 10 will continue burning pulverized coal until the reconstruction work will be started.
The sequence of the renovation works are as follows:

1) Reconstruction of boiler No.5
2) Connection of boiler No.7 to stack No. II, through flue duct of the boiler No.6

3) Sorting out of boiler No.4 and 6
4) Reconstruction of boiler No.7
5) Reconstruction of boiler No.9
6) Reconstruction of boiler No.10

On the other hand, the National Building Code prohibits to discharge the exhaust gases of gas combustion and fuel-oil combustion through the same duct. Accordingly, it is necessary to consult with the competent government office (National Fire Service Headquarters) in advance, concerning the operation plan if the fuel used in boilers No. 5 and 7 and that used in boilers No. 9 and 10 are different. Layout of boiler facilities in the boiler house after the renovation is shown in Figure 5.1.3.

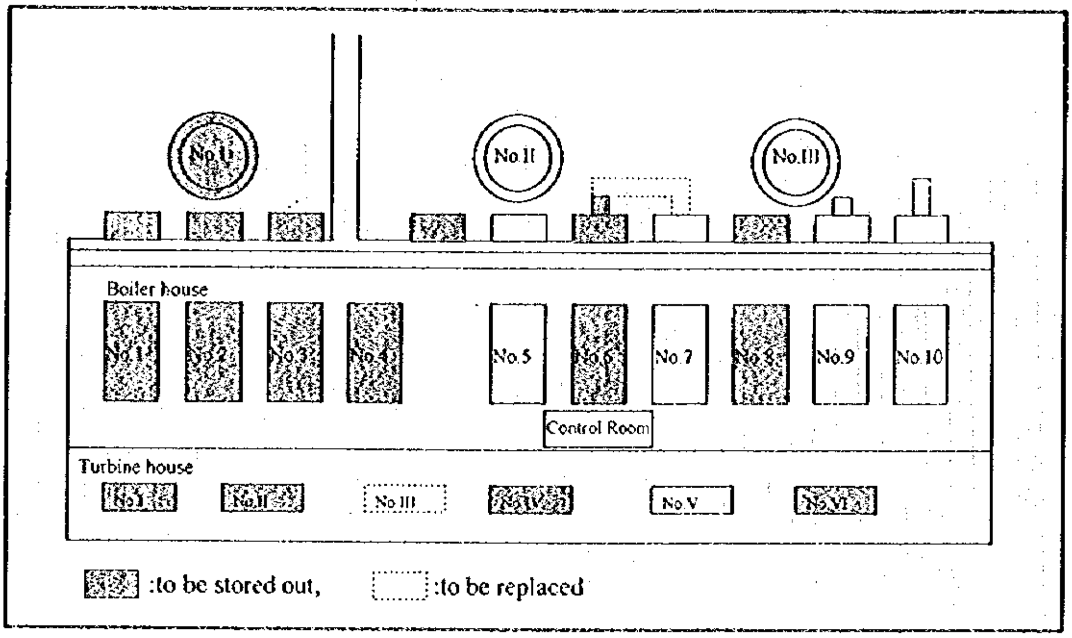


Figure 5.1.3 Layout of Existing Boiler Facility after Renovation

3) Sorting out of boiler No.4 and 6
4) Reconstruction of boiler No.7
5) Reconstruction of boiler No.9
6) Reconstruction of boiler No.10

On the other hand, the National Building Code prohibits to discharge the exhaust gases of gas combustion and fuel-oil combustion through the same duct. Accordingly, it is necessary to consult with the competent government office (National Fire Service Headquarters) in advance, concerning the operation plan if the fuel used in boilers No. 5 and 7 and that used in boilers No. 9 and 10 are different. Layout of boiler facilities in the boiler house after the renovation is shown in Figure 5.1.3.

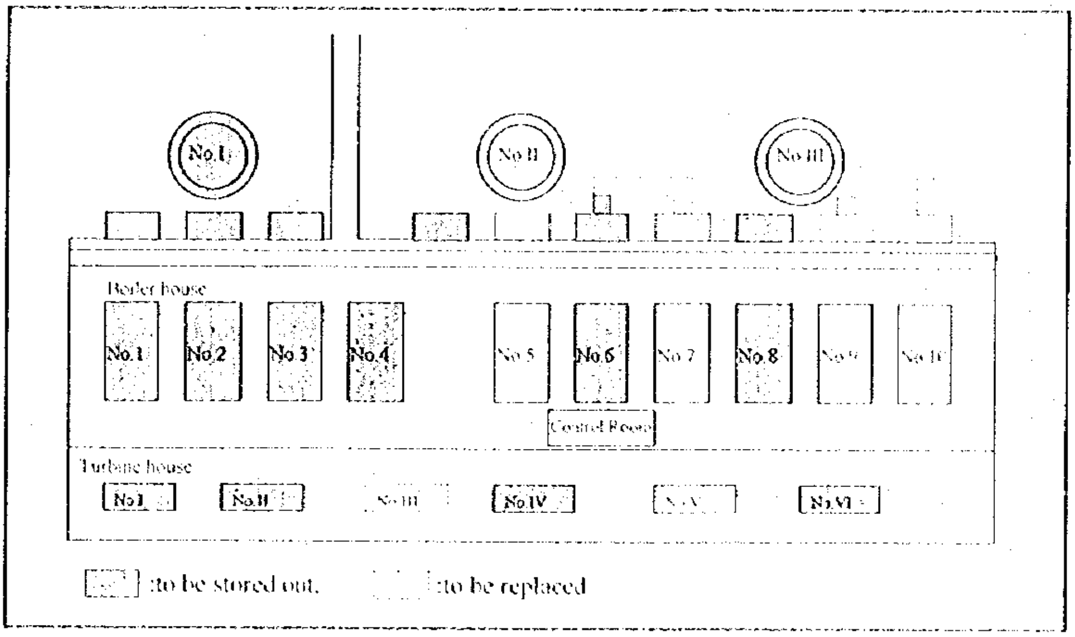


Figure 5.1.3 Layout of Existing Boiler Facility after Renovation

5.2 Fuel Supply

The existing renovated boilers will use natural gas as the main fuel, and use fuel oil only in the case of sudden shortage in gas supply or of planned interruption of operation.

The natural gas supply facility is used commonly by the renovated boilers and the new CFB boiler. The gas consumption by three existing boilers in operation after the renovation is 27,443 Nm^3/h.

Existing fuel oil supply system will be used as an auxiliary system for firing pulverized coal, but cannot be used for supplying the fuel to the renovated boilers. Therefore, the fuel oil facilities will be newly installed, but used together with the new 150MW unit.

The maximum consumption of fuel oil by one boiler after the renovation is 7,439 kg/h, with the rating of 110 t/h, and three boilers together consume 22,242 kg/h of fuel oil at maximum. This amounts to the maximum daily consumption of 510 tons.

It is necessary to install two highly accurate measuring systems for controlling fuels. Necessary measuring devices will be installed so as to enable exact measurement of fuel consumption by each of the burners or by each of the boilers, depending on the boiler control system.

5.3 Turbines and Electrical Facilities

(1) Turbines

With reconstruction of the 4 boilers, turbines will be operated as follows:

1) Until the renovation works of boilers are completed, the existing turbines will be used with necessary maintenance works

2) By the end of 2003, turbines No. I, II, III, IV, VI, and X will be abolished, and a new 32 MW double extraction (29 bars and 15 bars) condensing type turbine will be installed in the place of No. III turbine. The new turbine will supply steam and, when necessary, generate power with the existing 40 MVA generator.

3) Turbines No. V and VII will be used for the district heating.

The main characteristics of the new turbine are shown in Table 5.3.1.

Table 5.3.1 Main Characteristics of the New Turbine

Installed capacity		MW	32	32
Outdoor air temperature		°C	0	25
Live steam	Pressure	bar	74.50	74.50
	Superheating	°C	500.00	500.00
	Mass flow	kg/s	70.35	33.00
Extraction 1	Pressure	bar	30.00	30.00
	Temperature	°C	387.89	437.39
	Mass flow	kg/s	30.55	7.20
Extraction 2	Pressure	bar	15.00	15.00
	Temperature	°C	310.08	355.32
	Mass flow	kg/s	12.00	3.80
Condenser	Pressure	bar	31.66	105.45
	Temperature	°C	25.00	46.88
	Mass flow	kg/s	8.32	13.42
	Steam flow, volume	m^3	308.28	170.46
	Cooling zone	K	3.00	5.05
	Temperature gradient	K	10.00	16.82
Cooling water	Mass flow	kg/s	1,383.24	1,383.24
	Temperature(cold)	°C	12.00	25.00
	Temperature (warm)	°C	15.00	30.05
Feed water tank	Pressure	bar	13.50	100.00
	Temperature	°C	193.35	202.49
	Mass flow	kg/s	70.35	33.00
	Pressure	bar	100.00	100.00
	Temperature	°C	195.44	202.49
	Mass flow	kg/s	70.35	33.00
Power output		MW	31.99	19.82
Steam output		MW	132.50	35.33
Heat input		MW	180.77	83.76
Efficiency		%	90.99	65.85

Major works involved in the installation of the new turbines are as follows:

1) Construction of a turbine table as foundation
2) Installation of the turbine and auxiliaries
3) Tube connections
4) Provision of a control panel and connection to the existing system
5) Miscellaneous works

No significant changes are required for generators and transformers.

(2) Electrical Equipment

1) Electrical power demands and outlines

Simultaneous power demands after boiler conversion are as follows:

- per boiler	610 kW
- common type consumers of boilers	70 kW

Available power output due to eliminated coal-firing:

- at main boiler distributor, per boiler	1,260 kW
- at 3 kV, due to elimination of flue gas fan, per boiler:	336 kW
- at boiler distributor, per boiler:	12 kW

The mill legs on the 0.4 kV main boiler distributor will be eliminated in the course of the renovation.

The flue gas exhausting and air fan motors are supplied via frequency converter. Protection class of the frequency converter is IP54; it is placed in the 0.4 kV switching room.

2) 0.4 kV Main Distributor and Boiler Distributor

At both distributors, the power supply of new distributors can be provided by utilization and possible alteration of the branches of eliminated consumers.

A complete new jig design is only necessary for the branch of the flue gas recirculation blower motor in the boiler house. As far as the other consumers are concerned, the thermoswitch and possibly the fuse element has to be replaced.

3) Power Supply for Common Consumers

A new switchboard must be installed within the building of the oil pump house for such consumers as the new oil pump plant, the air compressor, control unit of burner combustion, and the main motor stop-valve of the gas system.

Also the power for the main gas stop-valve and the air compressor will be supplied via the station auxiliary switchboard.

(3) Control System

Figure 5.3.1 shows a concept of the control system of the reconstructed boilers.

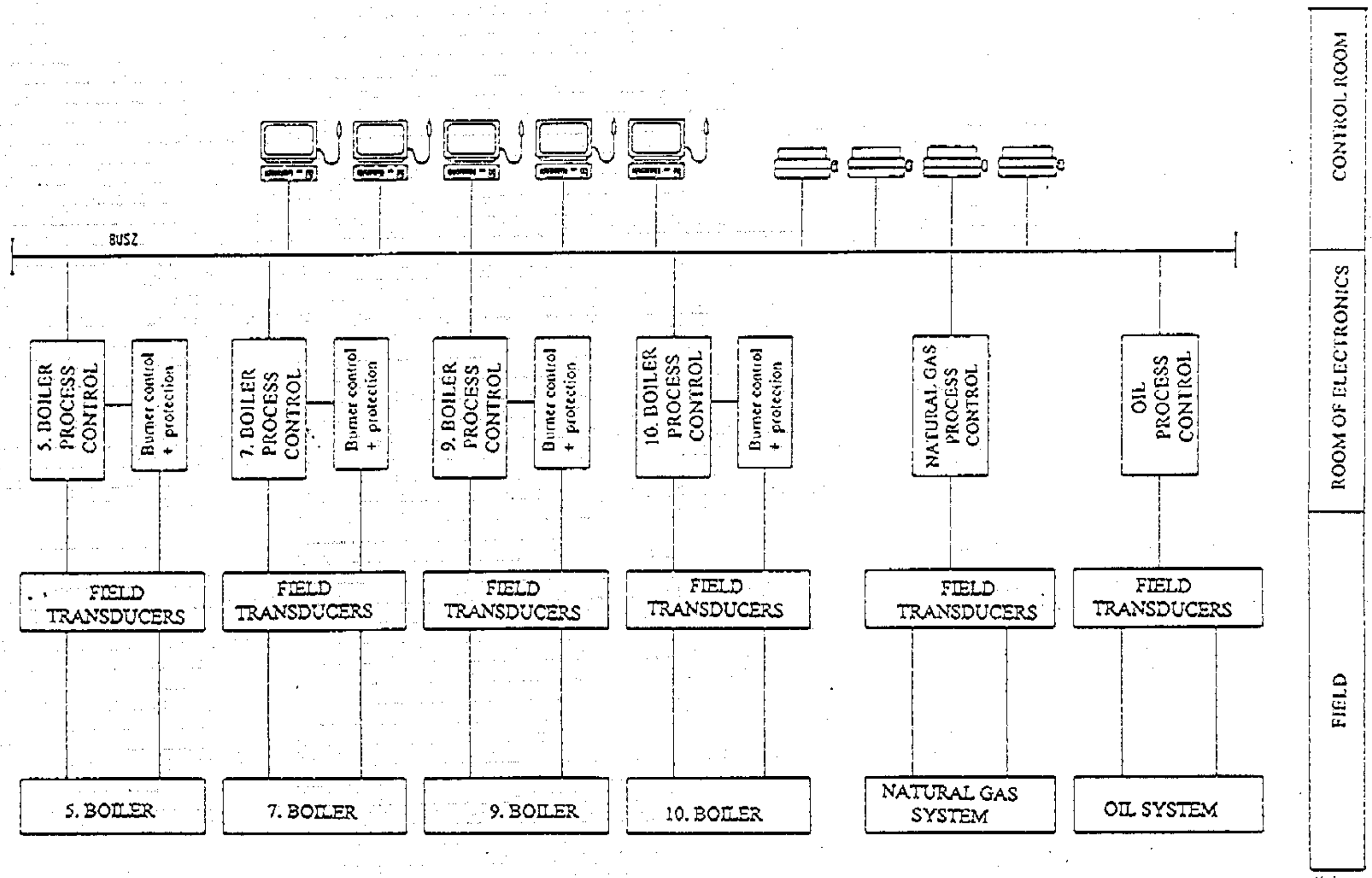


Figure 5.3.1 Concept of Control System

Chapter 6

Environmental Assessment and Protection Measures