6.5 Environmental Impact Assessment

6.5.1 Ambient Air Quality

The objectives of assessing environmental impact were the areas where this project will affect as well as the details and degree of such impact. The items assessed were SO_2 and NOx in flue gas. Prediction and analysis were based on the following four cases.

- Prediction of short-term concentration using plume model (Pre-analysis)
- Prediction of long-term average concentration of SO_2 using simulation models
- Modeling of stagnation (at calm and stagnated high concentration)
- Analysis of down-wash

(1) Prediction of Short-Term Concentration Using Plume Model

Ground-level concentration of SO_2 and NOx emitted from the Borsod Power Plant was calculated on the principal shaft downwind with Plume model. 30 minutes average was used for evaluated time. Calculation for prediction was made by the condition of emission from the Borsod Power Plant and by the weather condition. It was supposed that the contribution to the ambient air is achieved only by the emission from the Borsod Power Plant, and other emission sources are not be taken into account.

1) Flue gas data for diffusion calculation

In case of nominal load (full load), following conditions are established.

a) 150 MW (New 480 t/h boiler)

- Flue gas volume : 518,400 Nm^3/h (full operation)
- Flue gas temperature : 150 °C
- Stack height : 125 m (1 stack)
- Inside diameter of stack : ϕ4 m
- Data of flue gas : NOx $\leqq$ 200 mg/m^3 (104 kg/h)
  SO_2 $\leqq$ 400 mg/m^3 (207 kg/h)

b) Existing 4 boilers (100 t/h boiler)

- Flue gas volume : 532,800 Nm^3/h (full operation)
- Flue gas temperature : 150 °C
- Stack height : 101 m (2 stacks each stack for 2 boilers)
- Inside diameter of stack : ϕ4 m

- Data of flue gas :

i) In case of coal firing

$NOx \leqq$ 320 kg/h
$SO_2 \leqq$ 2910 kg/h (5462 mg/Nm^3) for domestic coal
(60% desulfurization efficiency)
1382 kg/h (2594 mg/Nm^3) for Import Coal

ii) In case of oil firing

- Flue gas volume : 450,000 Nm^3/h (full operation)
- Data of flue gas : $NOx \leqq$ 350 mg/m^3 (1575 kg/h)
  $SO_2 \leqq$ 1700 mg/m^3 (765 kg/h)

iii) In case of natural gas firing

- Flue gas volume : 450,000 Nm^3/h (full operation)
- Data of flue gas : $NOx \leqq$ 200 mg/m^3 (90 kg/h)
  $SO_2 \leqq$ 35 mg/m^3 (15.8 kg/h)

2) Condition for calculation

a) Boiler condition

- 100% load
- 75% load

b) Fuel condition

As given in the above item 1).

c) Atmospheric condition

- Pasquill's stability classification : Unstable (A - C), Neutral (D)
  Wind speed classification : 1, 3, 5, 7, 9 m/s

3) Plume diffusion calculation

a) Effective stack height

Effective stack height is given by the following formula.

$He = Ho + \Delta H$

where,

He	:	Effective stack height (m)
Ho	:	Real stack height (m)
ΔH	:	Rising height (m)

In case that wind speed exceeds 1m/s, ΔH is calculated by using CONCAWE formula.

$$\Delta H = 0.175 \cdot Q_H^{1/2} / u^{3/4}$$

where,

u	:	Wind speed at the top of stack (m/s)
Q_H	:	Heat emission of stack gas (cal/s)
		$Q_H = \rho \cdot Cp \cdot Q \cdot T$
ρ	:	Density of emitted gases at 0 ℃ = 1293 (g/m^3)
C_p	:	Specific heat at constant pressure = 0.24 (cal/ °K • g)
Q	:	Emission rate of gaseous effluent (Nm^3/s)
T	:	Temperature difference between atmosphere and emitted gas (Tc)
		T = Tc - 10 (℃)

b) Diffusion calculation formula

Plume diffusion calculation formula is applied for diffusion calculation. In case of exceeding wind speed of 1m/s, the following formula is applied.

$$c(x,y,z) = \frac{Q}{2\pi \cdot u \cdot \sigma_y \cdot \sigma_z} \exp\left(-\frac{y^2}{2\sigma_y^2}\right)\left[\exp\left\{-\frac{(z-He)^2}{2\sigma_z^2}\right\} + \exp\left\{-\frac{(z+He)^2}{2\sigma_z^2}\right\}\right]$$

where,

C(x, y, z)	:	Concentration at the location (x, y, z) (mg/m^3)
Q	:	Emission rate from emission resource (mg/s)
u	:	Average wind speed (m/s)
He	:	Effective height of emission resource (m)
σ_y, σ_z	:	Plume width along y and z axies, respectively (m)
x	:	Downwind distance along wind direction (m)
y	:	Rectangular horizontal distance against x axis(m)
z	:	Rectangular vertical distance against x axis(m)

c) Estimated width of diffusion

Width of diffusion was estimated according to Pasquill's method. Width of diffusion in the horizontal direction was set for averaged 30 minutes, which corresponded to the evaluated time(value in 30 minutes). It was also considered that the objective area is flat and does not need the correction applicable to an urban area.

4) Results of calculation

Table 6.5.1 shows calculated values of the maximum concentration on the ground by fuel kind, atmospheric stability and wind speed. Figure 6.5.1 show the attenuation of SO_2 and NOx concentration on the principal axis by fuel kind. From the results of calculation, it is concluded that the conditions of the cases that exceed the Environmental Protection Standards II are as follows.

Environmental Protection Standards II (value in 30 minutes)

SO_2 : 0.40 mg/m^3
NOx : 0.40 mg/m^3

<SO_2>

a) Atmospheric stability A, wind speed 1 m/s : case 1,2,4
b) Atmospheric stability B, wind speed 1 m/s : case 1

<NOx>

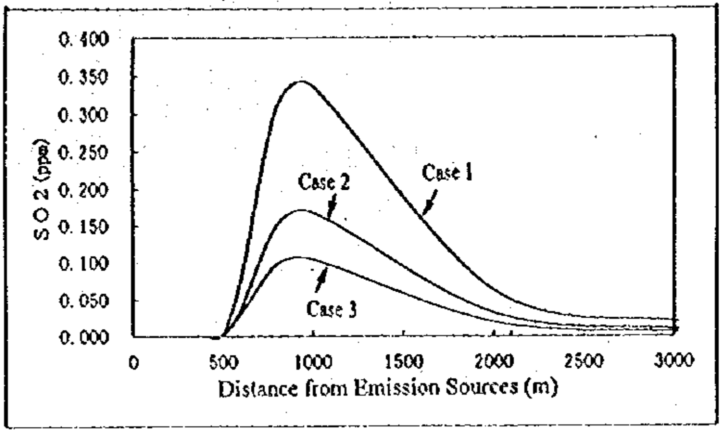
The concentration of NOx is 116μg/m^3 with the atmospheric stability A and wind speed of 1 m/s, and does not exceed the Environmental Protection Standards.

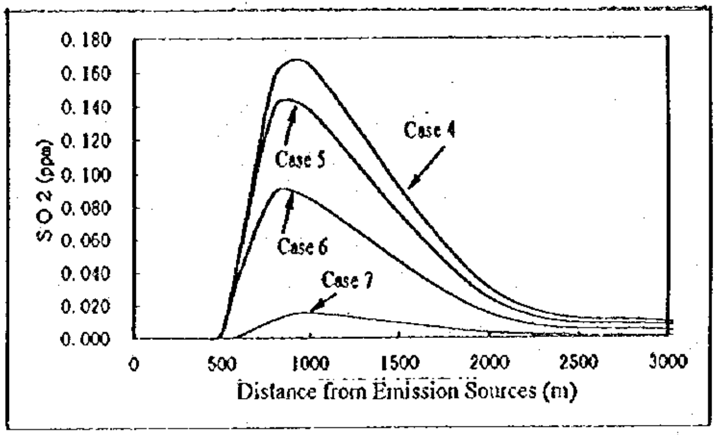
As mentioned above, emission standards of SO_2 applicable to each type of fuels can be satisfied, but the results exceed the Environmental Protection Standards in some cases. Actually, as the background concentration is added, total concentration becomes higher. From the viewpoint of environmental protection, it is insufficient just to satisfy the emission standards required for the reconstruction of the Borsód Power Plant. It is necessary to take the countermeasures to reduce the emission more strictly.

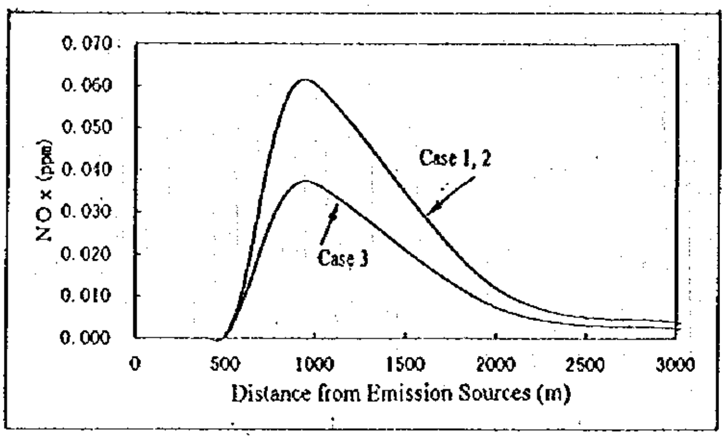
Table 6.5.1 Calculated Maximum Ground Level Concentration by Fuel kind, Atmospheric Stability and Wind Speed

Case	Boiler Condition	New (150MW) (H= 125 m)	Existing (H= 101 m)	No.	Atmospheric Stability (Pasquil)	Wind Speed (m/s)	SO2 Max. Concentration (mg/Nm3)	SO2 Max. Concentration (ppb)	SO2 Distance from the Source(km)	NOx Max. Concentration (mg/Nm3)	NOx Max. Concentration (ppb)	NOx Distance from the Source(km)
1	Full Operation	Exhaust gas = 518400 Nm3/h SO2 = 400 mg/m3 NOx = 200 mg/m3	Domestic Coal Exhaust gas = 532800 Nm3/h SO2 = 5462 mg/m3 NOx = 600 mg/m3	1	A	1	0.915	344.0	0.9	0.117	61.0	0.9
				2	B	1	0.471	177.0	3.0	0.059	31.0	3.0
				3	C	1	0.330	124.0	6.1	0.042	22.0	6.1
				4	C	3	0.338	127.0	3.1	0.044	23.0	3.1
				5	C	5	0.290	109.0	2.1	0.034	18.0	2.4
				6	C	7	0.274	103.0	2.1	0.032	17.0	2.1
				7	C	9	0.247	93.0	2.1	0.031	16.0	2.1
				8	D	5	0.133	50.0	8.3	0.016	8.6	8.3
2	Full Operation	Exhaust gas = 518400 Nm3/h SO2 = 400 mg/m3 NOx = 200 mg/m3	Mixture Coal Exhaust gas = 532800 Nm3/h SO2 = 2594 mg/m3 NOx = 600 mg/m3	9	A	1	0.455	171.0	0.9	0.117	61.0	0.9
				10	B	1	0.234	88.0	2.9	0.059	31.0	3.0
				11	C	5	0.144	54.0	2.2	0.034	18.0	2.4
				12	D	5	0.067	25.0	8.3	0.016	8.6	8.3
3	Full Operation	Exhaust gas = 518400 Nm3/h SO2 = 400 mg/m3 NOx = 200 mg/m3	Oil Exhaust gas = 450000 Nm3/h SO2 = 1700 mg/m3 NOx = 350 mg/m3	13	A	1	0.279	105.0	0.9	0.073	38.0	0.9
				14	B	1	0.149	56.0	2.7	0.036	19.0	3.0
				15	C	5	0.096	36.0	2.2	0.021	11.0	2.4
				16	D	5	0.043	16.0	8.3	0.010	5.1	8.3
4	75% Operation	Desulfurization 85 % Exhaust gas = 388800 Nm3/h SO2 = 1155 mg/m3 NOx = 200 mg/m3	Mixture Coal Exhaust gas = 399600 Nm3/h SO2 = 2594 mg/m3 NOx = 600 mg/m3	17	A	1	0.444	167.0	0.9	0.097	51.0	0.9
				18	B	1	0.234	88.0	2.8	0.052	27.0	2.8
				19	C	5	0.141	53.0	2.2	0.031	16.0	2.1
				20	D	5	0.067	25.0	8.1	0.014	7.5	8.0
5	75% Operation	Exhaust gas = 388800 Nm3/h SO2 = 400 mg/m3 NOx = 200 mg/m3	Mixture Coal Exhaust gas = 399600 Nm3/h SO2 = 2594 mg/m3 NOx = 600 mg/m3	21	A	1	0.380	143.0	0.8	0.097	51.0	0.9
				22	B	1	0.202	76.0	2.5	0.052	27.0	2.8
				23	C	1	0.149	56.0	5.7	0.036	19.0	5.8
				24	C	3	0.144	54.0	3.0	0.036	19.0	3.1
				25	C	5	0.125	47.0	2.2	0.031	16.0	2.1
				26	C	7	0.114	43.0	2.1	0.029	15.0	2.1
				27	C	9	0.098	37.0	2.1	0.025	13.0	2.1
				28	D	5	0.056	21.0	8.1	0.014	7.5	8.0
6	75% Operation	Exhaust gas = 388800 Nm3/h SO2 = 400 mg/m3 NOx = 200 mg/m3	Oil Exhaust gas = 337500 Nm3/h SO2 = 1700 mg/m3 NOx = 350 mg/m3	29	A	1	0.245	92.0	0.8	0.059	31.0	0.9
				30	B	1	0.133	50.0	2.3	0.031	16.0	2.5
				31	C	5	0.085	32.0	2.2	0.019	10.0	2.2
				32	D	5	0.040	15.0	8.1	0.009	4.8	8.1
7	75% Operation	Exhaust gas = 388800 Nm3/h SO2 = 400 mg/m3 NOx = 200 mg/m3	Gas Exhaust gas = 337500 Nm3/h SO2 = 35 mg/m3 NOx = 200 mg/m3	33	A	1	0.040	15.0	1.0	0.042	22.0	0.9
				34	B	1	0.021	8.0	3.1	0.021	11.0	2.8
				35	C	1	0.014	5.1	6.5	0.016	8.4	6.1
				36	C	3	0.013	5.0	3.2	0.016	8.3	3.1
				37	C	5	0.012	4.4	3.1	0.013	6.9	2.4
				38	C	7	0.010	3.8	2.6	0.012	6.4	2.1
				39	C	9	0.009	3.5	2.2	0.011	5.8	2.1
				40	D	5	0.005	1.8	9.0	0.006	3.2	8.1

(Atmospheric Stability : A, Wind Speed : 1.0 m/s)







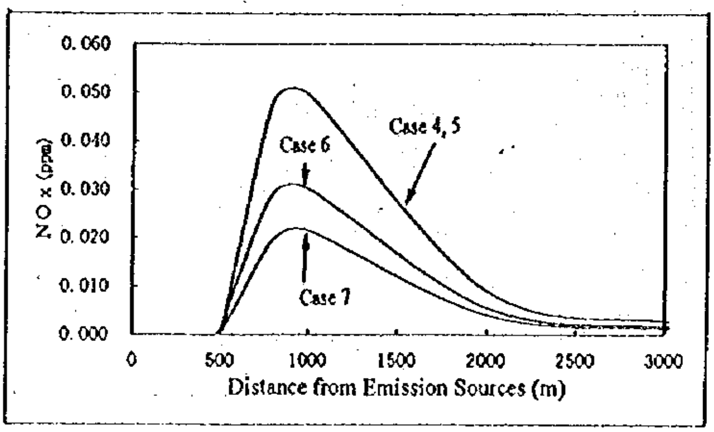
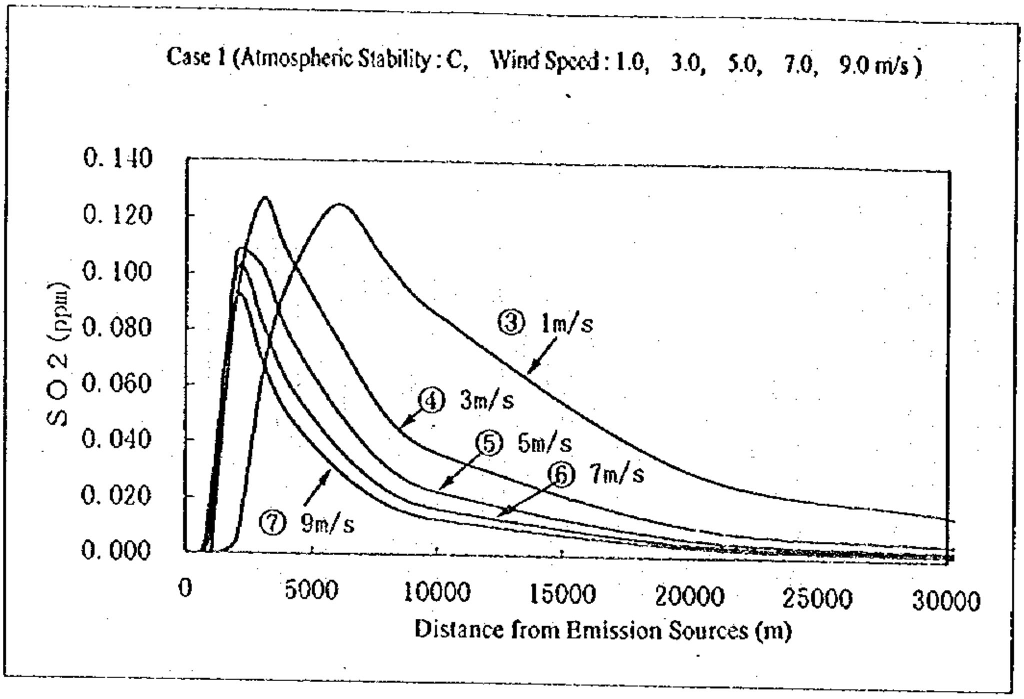


Figure 6.5.1 (1) Attenuation of SO_2 and NOx Concentration on Principal Axis by Fuel Kind

(Atmospheric stability: A)

Full Operation, New Boiler : Fixed Condition, Existing Boiler : Domestic Coal Combustion



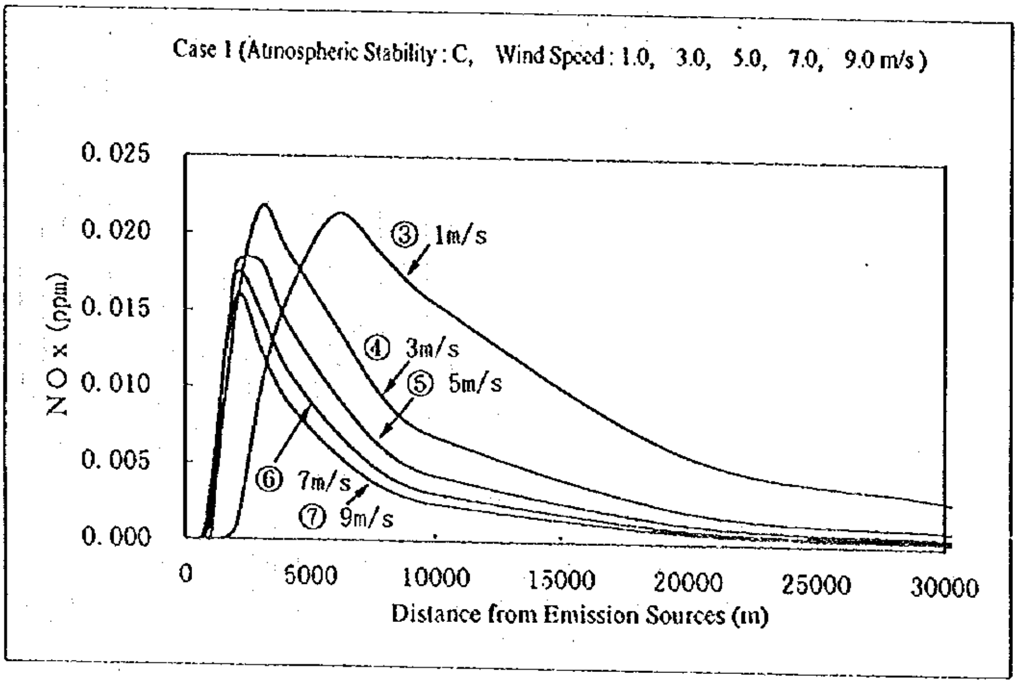


Figure 6.5.1(2) Attenuation of SO_2 and NOx Concentration on Principal Axis by Fuel Kind (Atmospheric Stability : C)

(2) Prediction of Long-Term Average Concentration of SO_2 Using Simulation Models

1) Preparation of basic model for prediction

This model is based on that used in "The Study on an Integrated Air Pollution Control Plan for Sajo Valley Area" conducted by JICA between 1992 and 1994 (hereinafter called " the previous JICA study"). For improving the model, existing data, information and future programs were also examined. Since this area is relatively flat, pollutant concentrations were calculated with a plume model.

a) Sources condition

i) Stationary sources

Table 6.5.2 shows the results of comparison made between the amount of air pollutants emitted in 1993 and 1995 from major stationary sources located within a circle with the radius of 20 km from the Borsod Power Plant. These data show the total of the amount declared by each enterprise. As this Table shows, the majority of SO_2 is emitted from the Borsod Power Plant (about 95% of total emission) and the amount emitted from other stationary sources are far less. Annual emission of SO_2 in 1993, compared to that in 1995, increased in the Borsod Power Plant but no remarkable changes can be observed in other major stationary sources. On the other hand, for NOx, power plants increased the emission remarkably while other sources decreased total emission remarkably. However, the data including exceptional ones cannot be used directly for the simulation. For example, the emission of NOx decreased by nearly 20 to 40% in Kahászati Betétel Keszit KFT while the concentration of SO_2 and dust was almost on the same levels. Taking into consideration the fact that large secular changes are not found in annual total emission of SO_2 and dust from other stationary sources than the Borsod Power Plant, and the data are based on the self-declaration made by the enterprises concerned, it is assumed that the present emission of SO_2 and NOx remains unchanged compared to that in 1993.

Furthermore, the gas flue data at Borsod Power Plant for diffusion calculation are as shown in (1) "Prediction of Short Term Concentration using Plume Model".

Table 6.5.2 Comparison of Annual Amount of Air Pollutant to Emitted

(Unit: kg/year)

Plant Name	Pollutant Materials	1993				1995			
		N1	N2	N3	N4	N1	N2	N3	N4
BORSODCHEM RT.	NOx (NO2)	3730	3773	1734	3815	1728	1621	1285	1766
	DUST	8986	10292	7516	8935	7336	7806	6625	7516
BORSODIHERMU *	SO2	9814393	3984671	3586201	6468420	9364922	6413347	4059615	9088509
	NOx (NO2)	200594	115809	96951	158531	645595	442546	279925	626549
	DUST	462802	229256	198230	390139	496845	334840	199915	428125
YTONG BORSOD-FALAZOELEMGYARA	DUST	812	2007	1909	1130	1767	2041	2101	1817
ESZAKMAGYARORSZAGI VEGYIMUVEK	SO2	0	0	0	0	0	0	22877	91317
	NOx (NO2)	0	0	0	0	0	0	4091	16102
	DUST	0	0	0	0	0	0	1244	4950
INTERMED KFT.	SO2	117	192	68	17	0	0	0	0
	NOx (NO2)	0	50	50	0	0	0	0	0
	DUST	176	144	209	106	0	0	0	0
PORAN POLIURETAN GYARTO ES ERTEKESITO KFT.	NOx (NO2)	0	0	0	0	0	0	0	0
SAGROCHEM KFT.	SO2	0	99259	146448	104141	0	0	0	0
	NOx (NO2)	31	7970	11743	8289	0	0	0	0
	DUST	27	2396	3544	2523	0	0	0	0
KOHASZATI BETETEL KESZIT KFT.	SO2	243750	139191	244440	259791	257760	215450	177480	237153
	NOx (NO2)	138475	76619	137744	132725	35825	29460	24484	30960
	DUST	469796	260540	468126	451066	508770	428416	349468	461841
KOZUZEMI SZOLGALTATO INTEZMENY. MORA FERENC U. 30. SZ. KAZANHAZ	NOx (NO2)	0	0	0	0	130	32	22	119
KOZUZEMI SZOLGALTATO INTEZMENY. 24. SZ. KAZANHAZ	NOx (NO2)	0	0	0	0	151	57	22	108
KOZUZEMI SZOLGALTATO INTEZMENY. KOSSUTH UTI KAZANHAZ	NOx (NO2)	0	0	0	0	130	50	14	67
KOZUZEMI SZOLGALTATO INTEZMENY. PET FIU. 6. SZ. ALATTI KAZANHAZ	NOx (NO2)	0	0	0	0	130	54	42	97
PANNONGLAS IPARI RT. SAJOSZENTPETERI UVEGGYAR	NOx (NO2)	78196	101572	116262	112972	74643	79805	116299	116322
	DUST	17216	20696	25962	26906	19543	23686	33126	32886
ESZAKMAGYAR TEGLAIPARI RT. PUTNOKI TEGLAGYAR	SO2	16759	93276	94301	95626	26133	93290	94315	94315
	NOx (NO2)	1526	8951	9049	9132	2524	9009	9108	9108
	DUST	1463	3036	3069	3621	1046	3756	3798	3798
Note: N1 : January ~ March; N3 : July~September	TOTAL (ネボルショド発電所	SO2 : 1537376				SO2 : 1310090			
N2 : April ~ June; N4 : October ~December	のデータは除く)	NOx (NO2) : 964408				NOx (NO2) : 565365			
		DUST : 1802359				DUST : 1913337			

ii) Automobile

To catch the present situation of emission loads by automobiles, it is necessary to clarify the emission factors by the car types and the traffic volume. Therefore, the data concerning the traffic in Sajo Valley, Borsod County, Hungary, was collected and arranged.

Figure 6.5.2:	Traffic survey points and major roads network in study area
Table 6.5.3:	Yearly variation of traffic volume by car type
Figure 6.5.3:	Yearly variation of traffic volume by survey points
Table 6.5.4 & Figure 6.5.4:	Total traffic volume by survey point
Table 6.5.5:	Registered car numbers and average car ages by car name in Borsod County
Table 6.5.6:	Distribution of the car ages by car types in Hungary

Based on the results of survey, the situation is understood nearly as follows.

- On the national roads in Sajo Valley, decrease in the number of trucks is found in 1995 compared to that in 1990, but total amount of traffic expressed in the number of running automobiles is nearly the same (Figure 6.5.2 and Table 6.5.3).

- The number of registered types with larger emission factor of NOx including Dacia, Lada, Trabant and Skoda tends to decrease while that of European and Japanese automobiles with smaller emission factor of NOx including Audi, Opel and Mazda tends to increase. Total number of automobiles registered tends to increase (Table 6.5.5).

- According to the distribution of the ages by the car types, every type is becoming older (Table 6.5.6).

In the above mentioned overall trends, the number of old type automobiles running has decreased notwithstanding the number of automobiles registered. Due to this reason, the emission of NOx and CO tends to decrease. On the other hand, the adoption of diesel engines for small trucks is in rapid progress in recent years in Hungary. The opinion of the Hungarian people concerned including those in traffic control bureau and traffic science institute is that the overall emission has not substantially changed. This opinion is most probably reflecting the actual situation.

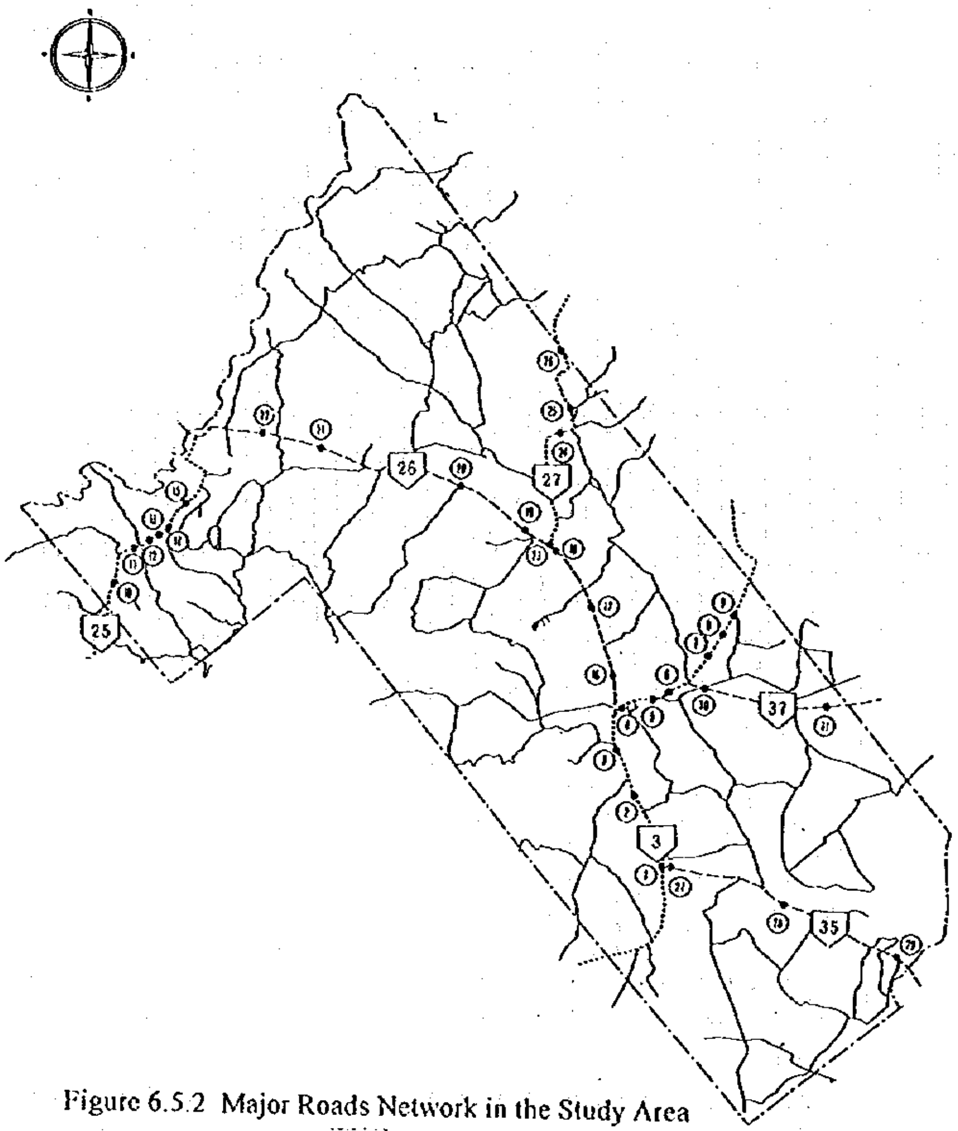


Figure 6.5.2 Major Roads Network in the Study Area

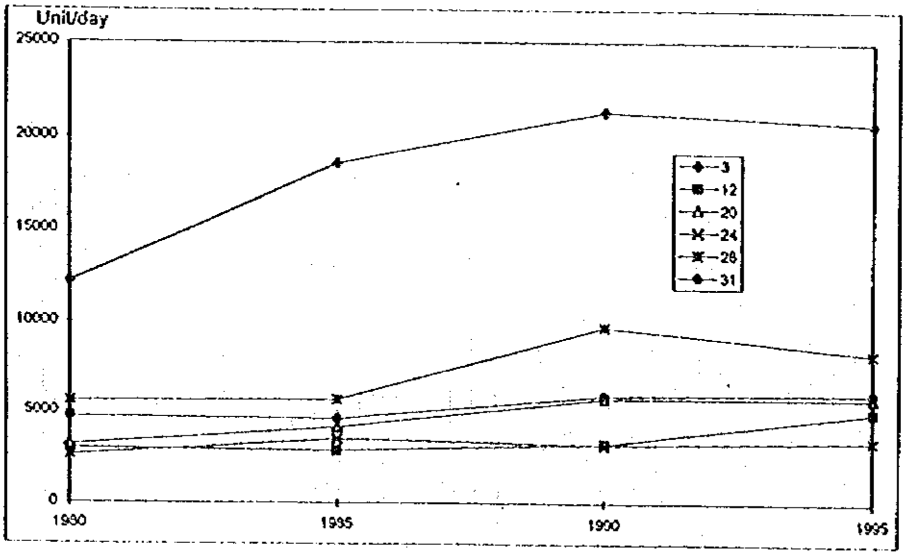


Figure 6.5.3 Trends in Traffic Volume

Table 6.5.3 Trends in Traffic Volume by Car Type

(units/day)

Type	Point	Road no.	Year 1980	1985	1990	1995
Passenger Car	3	3	8107	13241	16413	17889
	12	25	2049	1803	2640	4357
	20	26	2028	2685	3957	4366
	24	27	1732	2172	2080	2922
	28	35	2917	3008	6730	6095
	31	37	2660	2812	4401	4857
Bus	3	3	720	939	571	495
	12	25	289	194	130	140
	20	26	113	223	284	253
	24	27	208	225	279	138
	28	35	217	188	159	193
	31	37	180	107	85	75
Truck	3	3	3368	4381	4306	2286
	12	25	643	862	448	454
	20	26	1039	1228	1502	1137
	24	27	663	1113	820	335
	28	35	2460	2473	2823	1958
	31	37	1883	1678	1433	1090
Total	3	3	12195	18561	21290	20670
	12	25	2981	2859	3218	4951
	20	26	3180	4136	5743	5756
	24	27	2603	3501	3179	3395
	28	35	5594	5669	9712	8236
	31	37	4723	4597	5919	6022

Table 6.5.4 Traffic Volume in 1995 by Survey Points

(Unit:Veh/day)

Road No.	Point No.	Point	Passenger Car	Buses	Coupled Buses	Truck Small	Truck Large	Truck Trailer	Total
3	3	172+500	17889	393	102	285	1086	915	20670
25	12	67+000	4357	115	25	197	168	89	4951
26	20	23+000	4366	217	36	284	514	339	5756
27	24	9+500	2922	115	23	50	208	77	3395
35	28	10+000	6095	168	15	188	520	1250	8236
37	31	13+800	4857	75	0	126	482	482	6022

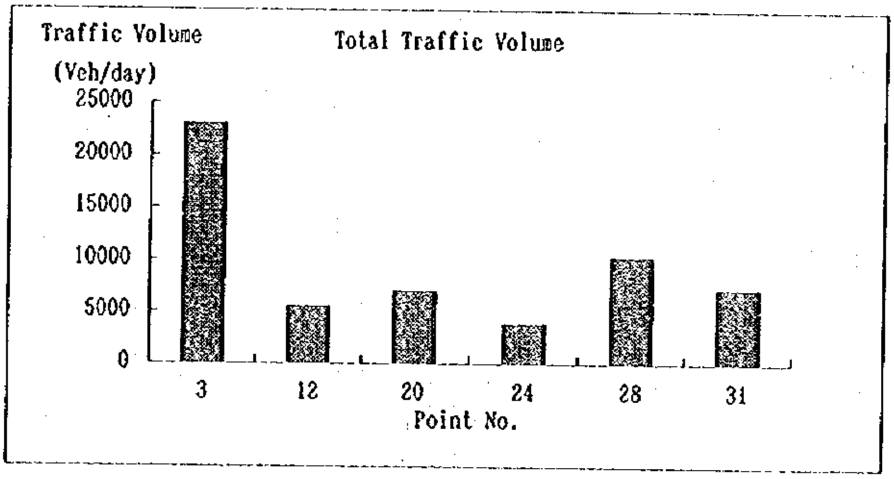


Figure 6.5.4 Traffic Volume in 1995 by Survey Points

Table 6.5.5 Registered Car Numbers and Average Car Ages by Car Names in Borsod County

Name	Registered Car Number				Average Car Age			
	1992	1993	1994	1995	1992	1993	1994	1995
Ebbol Audi	499	926	1071	1279	9.54	10.71	11.30	11.23
BMW	341	573	647	771	10.13	10.75	11.35	11.22
Citroen	396	640	735	1006	7.72	8.68	9.49	9.84
Dacia	8775	5893	4479	2499	6.00	7.26	8.60	10.13
Daihatsu	127	198	242	288	5.03	5.65	6.47	7.82
Datsun-Nissan	382	738	891	1128	7.38	8.13	9.00	9.77
Fiat	1435	2208	2602	3431	11.68	10.86	11.24	10.58
Ford	1192	2410	2918	3906	14.31	8.76	9.36	9.56
Honda	240	417	479	618	7.75	8.29	8.94	9.47
Lada	31199	31511	29968	29905	10.48	10.78	11.33	12.14
Lancia	90	169	224	307	7.85	8.77	9.65	10.17
Maruti	312	403	425	465	1.88	2.48	3.37	4.27
Mazda	490	934	1112	1394	7.42	8.05	8.81	9.41
Mercedes	466	748	884	1146	11.76	12.09	12.60	13.12
Mitsubishi	324	646	754	978	6.84	7.95	8.86	9.24
Moszkvics	1384	1315	1265	1109	10.31	10.29	10.85	11.74
Oltcit	96	96	93	73	2.96	3.87	4.75	5.86
Opel	1447	3059	3903	5337	8.02	7.89	8.02	7.90
Peugeot	523	773	896	1139	5.80	7.28	8.36	8.79
Polski Fiat	5075	4903	4786	4605	9.65	10.36	11.26	12.19
Porsche	9	17	19	24	11.05	11.26	11.39	13.03
Renault	692	1305	1640	2905	8.71	8.89	9.20	9.49
Seat	77	178	237	460	4.56	4.66	5.37	5.21
Simca	106	173	199	199	11.37	11.69	13.22	13.10
Skoda	13344	12845	12559	12287	10.54	11.08	11.82	12.64
Subaru	44	86	108	435	8.50	9.17	10.64	10.08
Suzuki	86	668	1146	2083	4.79	1.76	2.25	2.34
Toyota	352	710	863	1152	7.23	7.95	8.78	9.19
Trabant	23797	22215	21741	21523	9.04	9.57	10.44	11.36
Uaz	218	173	163	142	10.77	11.37	12.36	12.94
Volga	377	247	186	135	9.39	10.07	11.53	12.94
Volkswagen	1773	3576	4196	5297	12.13	11.90	12.39	12.27
Volvo	115	188	214	254	11.04	10.92	11.38	11.87
Wartburg	15148	13884	13459	13094	10.02	10.53	11.32	12.18
Zaporozsec	328	326	374	444	15.62	14.07	12.76	11.24
Zasztava	1312	1350	1351	1334	7.10	8.01	9.00	9.84
Total and Average	112571	116501	116829	123152	9.54	10.01	10.67	11.13

Table 6.5.6 Distribution of Car Ages by Car Types in Hungary

(Unit:%)

Type	Vehicles Age in Years			
	<1	2-5	6-10	10<
Year	1990			
Passenger Car	4.3	27.8	25.9	42.0
Buses	1.2	33.7	34.0	31.1
Truck	4.3	33.2	34.9	27.6
Year	1995			
Passenger Car	2.3	8.1	41.5	48.1
Buses	4.0	16.1	39.3	40.6
Truck	4.9	17.8	36.1	41.2

Taking into account the above mentioned situation, the conditions applicable to the emission from automobiles are regarded as the same as those applied in 1993.

iii) Area sources

As in the case of the previous JICA study, area sources are considered to include small-scale stationary sources and traffic on narrow roads in addition to those arising from the domestics. For the area sources arising from the domestics, it is possible to estimate the situation of fuel conversion by examining the local gas supply by gas supply companies. Table 6.5.7 shows the trend of the gas supply by gas supply companies in the area. This Table also shows estimated future for gas companies.

Gas consumption by the domestics tends to increase. In particular, the increase in 1996 is extreme. This consumption exceeds that estimated for 2001. Probable cause is the exceptionally severe coldness in this year. The consumption is estimated less in normal years. The extent of SO_2 and NOx arising from small-scale stationary sources and traffic on narrow roads is supposed to be nearly unchanged compared to that in 1993 due to present economical situation still far from the recovery. Such tough situation can be also estimated from the unchanged increase of the supply of natural gas consumed by other demand than that by enterprises and domestics.

For the above mentioned reasons it was decided to handle the discharging conditions for each source as the same as in 1993, and to conduct predictive calculation on the assumption that air pollution measures had been taken.

b) Meteorological condition

It was decided to handle the meterological conditions as the same as at the time of the previous JICA study.

c) Diffusion equation

The diffusion equation for each of point, line and area sources were based on the Plume model as shown in the previous JICA study.

Table 6.5.7 Trend of Gas Supply Company in Study Area

Month	1994			1995			1996		
	Communal Consumer Points	Communal Consumers m³	Total m³	Communal Consumer Points	Communal Consumers m³	Total m³	Communal Consumer Points	Communal Consumers m³	Total m³
Jan	112,138	21,198,692	41,249,276	122,968	14,581,858	55,472,136	133,211	32,785,295	58,925,732
Feb	112,616	21,240,959	41,349,833	123,861	24,787,341	42,939,211	133,858	34,989,868	59,909,812
Mar	112,928	20,488,171	37,623,293	124,099	19,658,359	37,043,672	134,079	31,397,009	53,322,955
Apr	113,481	13,249,802	25,869,581	124,308	16,948,517	30,576,541	134,400	19,773,736	34,207,970
May	113,723	6,530,117	16,149,681	124,510	7,955,352	17,163,251	134,701	5,471,008	14,530,748
Jun	114,050	4,256,016	12,785,833	124,862	4,919,219	13,408,715	134,214	3,916,565	12,749,770
Jul	114,458	2,003,515	10,362,739	125,162	2,148,883	10,795,006	134,513	1,349,834	10,498,784
Aug	114,913	1,899,603	10,754,419	125,549	2,135,705	10,623,213	134,925	1,755,715	10,670,274
Sep	115,792	3,911,920	12,786,418	126,390	4,760,384	13,971,765	135,643	6,203,449	17,182,273
Oct	118,105	6,284,848	21,692,423	127,961	5,826,531	19,970,658	136,785	8,981,740	24,018,647
Nov	120,354	15,528,382	35,237,328	129,700	16,577,926	38,299,579	137,162	17,810,000	37,996,000
Dec	122,419	25,008,631	47,822,940	132,019	25,261,036	48,839,930	138,192	31,897,000	53,422,000
Total		141,600,656	313,683,764		145,561,111	339,103,677		196,331,219	387,434,965

Note:Predicted Including Business Establishments
Heating Value is 34 Mj/m³

Planned

Year	Communal Consumer Points	Communal Consumers m³	Total m³
1997	143,467	175,766,000	354,614,600
1998	146,987	182,471,000	364,134,200
1999	149,762	186,801,000	369,040,900
2000	152,169	190,172,000	372,903,800
2001	154,445	193,981,000	377,216,400

2) Prediction results for long-term average SO_2 and NO_2 concentrations.

In the predictive calculation, source conditions at other areas than Borsod Power Plant were used as they were now. The predictive calculation was performed on the following condition adopting CFBC to the newly installed boiler.

- Heating period average of SO_2 (Figure 6.5.5)

  75% load
  Existing boiler: natural gas

- Yearly average of SO_2 (Figure 6.5.6)

  75% load
  Existing boiler: mixed coal

- Heating period average of NO_2 (Figure 6.5.7)

  Full load
  Existing boiler: domestic coal

Air quality environmental protection standards for the yearly average of SO_2 and NOx are as follows.

(unit : mg/m^3)

Item	Protected Area	
	I	II
SO_2	0.070	0.100
NOx	0.100	0.150

a) Even if using natural gas, the cleanest fuel in the existing boiler, SO_2 in the heating period exceeds the environmental protection standard I for residential areas in the vast area including the cities of Kazincbarcika, Sajoszentpeter and Miskolc. Even the Environmental Standard II applicable to industrial districts has not been cleared in Miskolc.

b) When using mixed coal in existing boilers, the Air Quality Environmental Protection Standard I for the yearly average SO_2 has been met in all other areas than Miskolc.

c) NO_X in the heating period is a calculation example in the full load and worst condition, but has cleared the Air Quality Environmental Protection Standard I in all areas.

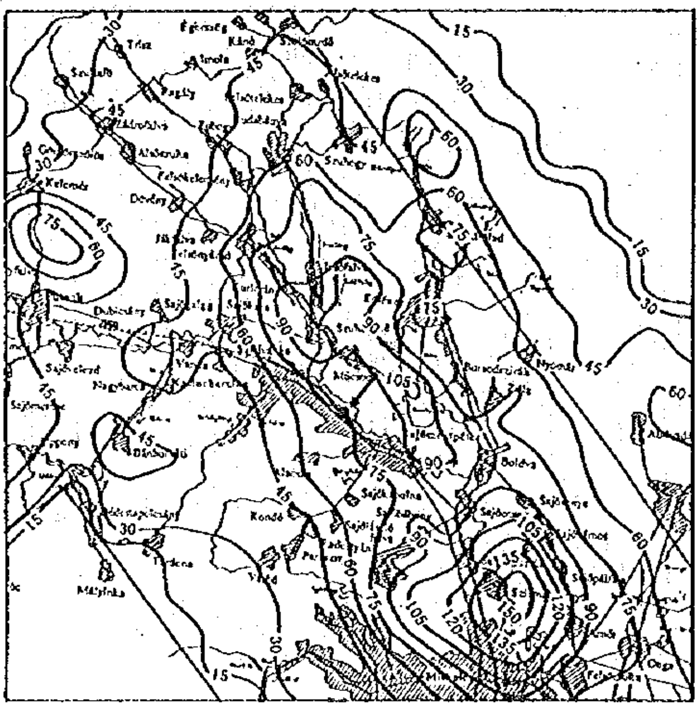


Figure 6.5.5 Isopleth for SO_2 in Heating Season

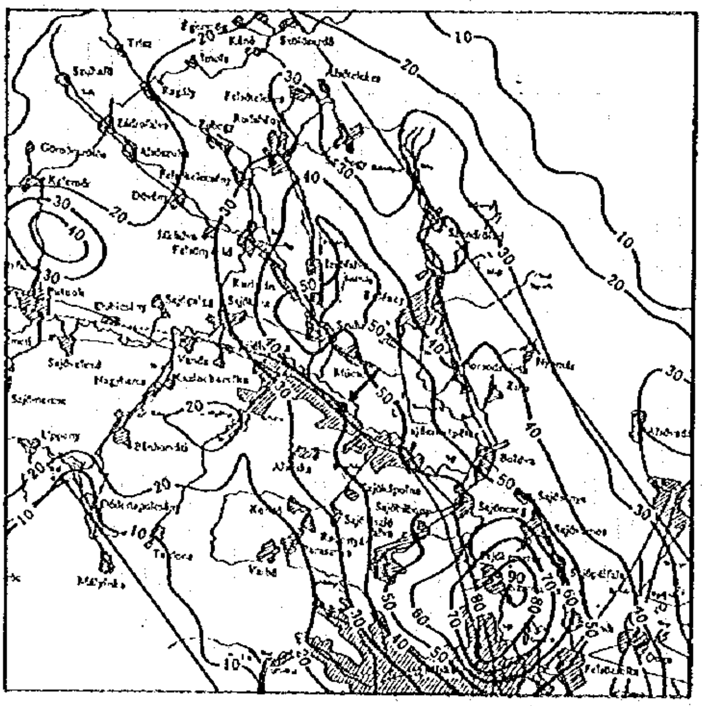


Figure 6.5.6 Annual Average Concentration Isopleth for SO_2

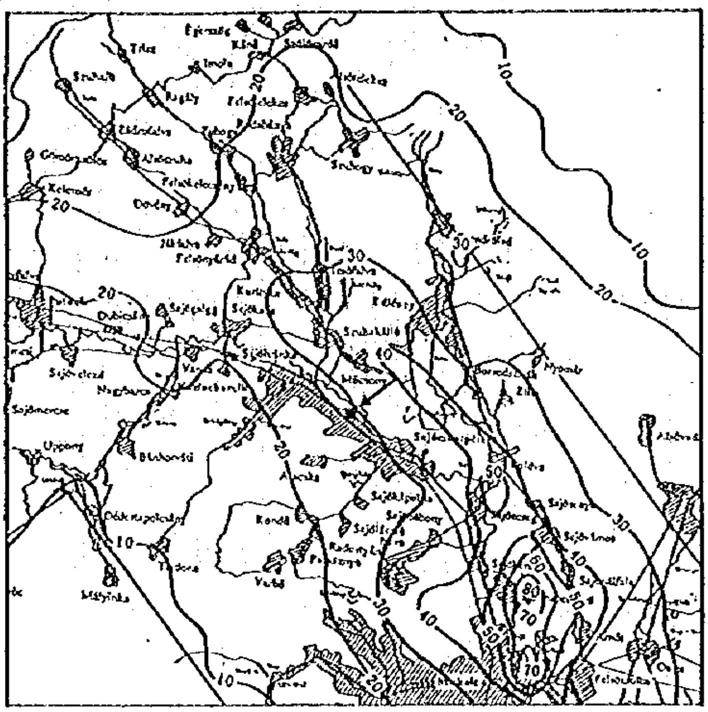


Figure 6.5.7 Isopleth for NOx in Heating Season

d) This indicates that, although the effect of the air pollution control measures at Borsod Power Plant is contributing to lowering the local SO_2 concentration level, there still remains a large influence from other sources led by the area sources. It is indicated that, in order to clear the environmental protection standard at the heating period, it is necessary to take measures for other sources also than the power plant.

e) Taking Jan. 1, 2005 as a goal when a new emission standard comes into effect, it is considered possible for the SO_2 value to clear the environmental standard on the following conditions.

- That the emission standard for other stationary sources is also cleared.
- That the fuel conversion from solid fuel to natural gas planned for the residential areas as the center is steadily implemented.

(3) Stagnation (calm and stagnated high-concentration) Modeling

Stagnated high-concentrations of pollutants occur mainly in the winter season. They were observed a number of times during the period of the previous JICA study. Figure 6.5.8 (upper) is an example of concentration isopleth of SO_2 at 12:00 ~13:00 on November 23, 1993.

The wind speed and direction on the ground were 0.9m/s and ESE, and a high concentration of 0.5 ppm was observed at 5-6 km from Borsod Power Plant. The highest concentration can be assumed to be at least 0.6 ppm from the concentration isopleth. In Borsod Power Plant at that time, four units of 100t/h boilers, No. 5, 6, 7 and 8, were operating at 70-80% load. The background concentration can be assumed to be about 100 ppb from the concentration isopleth.

As predictive calculations are difficult with ordinary diffusion equations, concentrations on the ground after the reconstruction of the Plant were calculated by taking into account that the ground-level concentration varies in inverse proportion to the square of the effective stack height and in proportion to the SO_2 emission.

Supposing the operation loads of 75% and 100% for the new boiler and the existing boilers, respectively, a calculation was made on the ambient air quality in the case the existing boilers use natural gas. Various conditions such as meteorology were assumed to be the same as that for the upper figure of Figure 6.5.8. The result is shown in Table 6.5.8 and the lower part of Figure 6.5.8.

When the planned measures are effected, the ambient air quality standard of SO_2 for protected areas II, 0.40 mg/m^3 (150ppb), applicable to factory areas is satisfied, but as for protected areas I, 0.25 mg/m^3 (94ppb), applicable to residential areas, it is already exceeded by the background concentration alone. The contribution by Borsod Power Plant is maximum 32ppb with the newly installed stack height of 130m, and 35ppb even with the stack height of 125m. The contribution of the Power Plant is substantially reduced, but it is necessary to control other sources.

According to the plan of the gas supply company covering the whole investigation area, use of natural gas in place of coal for home heating is gradually progressing; users are expected to increase from 138,192 in 1996 to 154,445 in 2001.

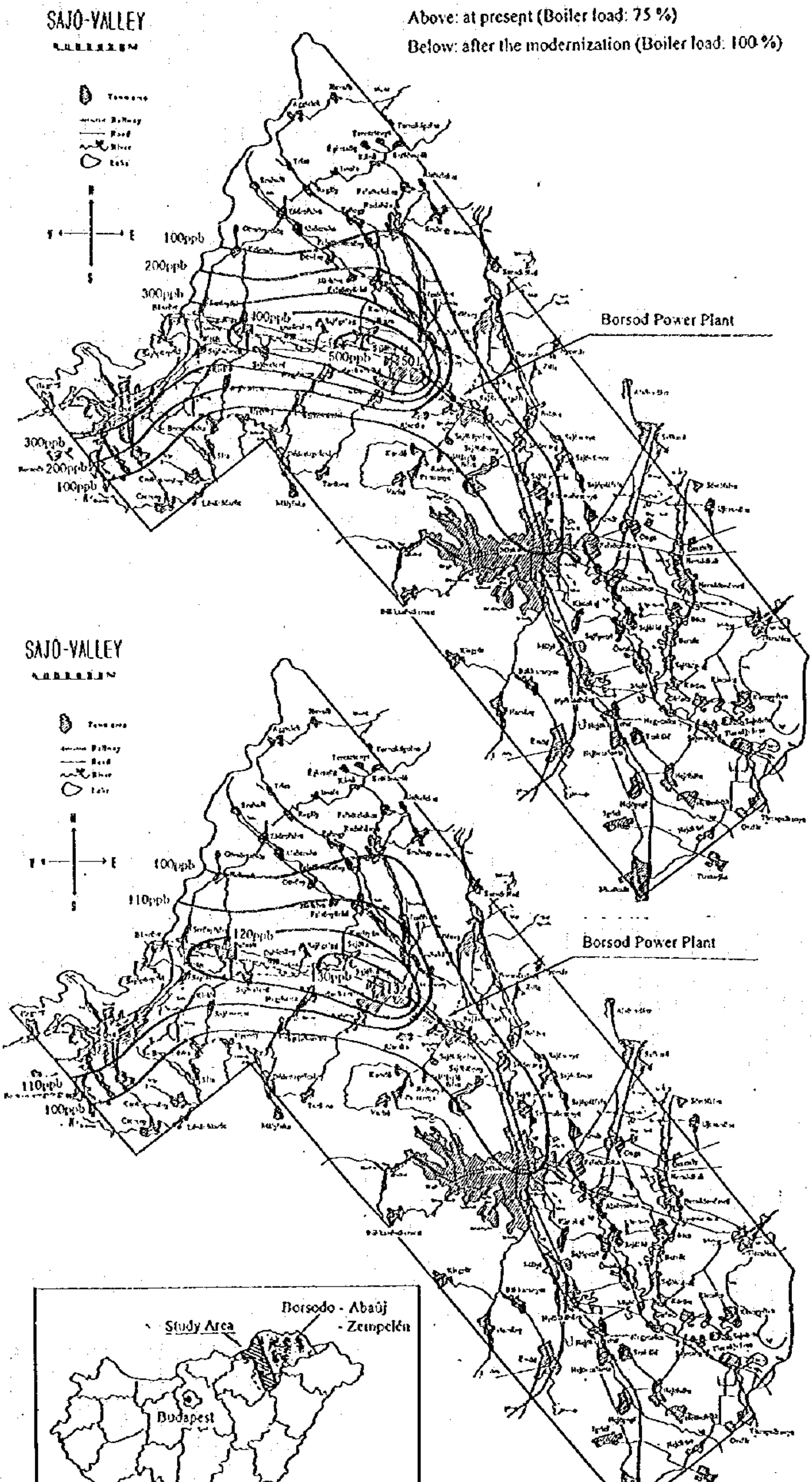


Figure 6.5.8 Isopleth for SO_2 at Stagnant Weather Condition by All Types of Sources

Regarding stationary industrial sources also, the regulations by EKF are considered to be strengthened. Therefore, as long as environmental protection measures are sufficiently taken by Borsod Power Plant which has been emitting a large amount of SO_2, it will be possible to meet the standard for protected areas I in the near future even under the specific weather conditions such as the stagnation.

Table 6.5.8 Prediction Results of SO_2 Concentrations During Stagnation

	Boiler condition	Fuel condition		Discharge condition				Maximum on-ground concentration
		New (150MW)	Existing	New (H=130m)		Existing (H=101m)		
				Exhaust gas	SO_2	Exhaust gas	SO_2	SO_2
				Nm^3/h	mg/Nm^3	Nm^3/h	mg/Nm^3	ppb
high-concentration instance (data of 1993)	75% operation	-	Domestic coal	-	-	399,600	5,462	500
Concentration estimable from discharge	Full operation	-	Domestic coal	-	-	532,800	5,462	667
	75% operation	Pulverized coal*	Gas	388,800	400	337,500	35	24
	Full operation	Pulverized coal*	Gas	518,400	400	450,000	35	32

* Emission standards (SO_2=400mg/m³, NO_2=200mg/m³) are satisfied.

(4) Downwash

The exhaust gas emitted from the stack can be caught by the swirl occurring in the back of stack or caused by the nearby building, and falls to the ground rapidly. This phenomenon is called a downwash which increases the pollutant concentration on the ground near the stack.

In the Clean Air Act Amendments, the US EPA sets forth the regulation of Good Engineering Practice (GEP) to prevent downwash. GEP stack height is " the stack height which guarantees that the downwash and swirl or turbulence caused by nearby buildings, topographical barrier, or the stack itself does not influence the exhaust gas from the stack or bring about the high-concentration air pollution in the vicinity of the smoke source". In this report, the GEP stack height was calculated using BPIP (Building Profile Input Program) (1993) prepared by the US EPA.

As shown in Table 6.5.8, as exhaust gases from the existing stacks are natural gas combustion exhaust gases, the discharge of air pollutants from stacks is small. As regards the high-concentration air pollutants due to downwash, it is necessary to consider the coal firing exhaust gas from the newly installed stack.

Therefore, calculation of GEP stack heights was made against the newly installed stack only.

The positions of power plant facilities and buildings required for calculating GEP stack height are given in the layout for the plant facilities in Section 3.4. The design values in Chapter 4 were used as to the height of each facility and building.

Results of GEP stack heights calculation are shown in Table 6.5.9.

The results show that the GEP stack height is 130m. As the height of the newly installed stack is designed to be 130 m, the downwash will not occur.

6.5.2 Groundwater

As the area concerned is an industrial area, the groundwater sources are exposed to various dangers. In particular, the aquifer for the drinking water source is located near the ground level.

(1) Prediction and Evaluation of Environmental Impact

If sufficient measures were not taken in the coal ash storage area as well as for the legal and illegal dumping of wastes from Borsod Power Plant and Borsodchem Co., it would not be possible to expect the groundwater pollution to be improved, and the source of trouble would be left for the future.

At Borsod Power Plant presently, they are implementing measures for alleviating contaminating effects on the groundwater by means of a transport technique of thick sludge instead of thin sludge. Borsodchem Co. also is taking and planning control measures. The Study Team estimated and evaluated future environmental conditions in a case where groundwater contamination from Borsod Power Plant facilities is thoroughly prevented with a impermeable sheet technique etc.

Table 6.5.9 Stuck Height by GEP Model

Wind Direction		New Stack			
		BH	PBW	Wake Effect Ht (GEP Ht)	Building contributing to Wake Effect Ht
degree	-	m	m	m	-
11.25		-	-	-	-
22.50	NNE	-	-	-	-
33.75		54.00	36.69	109.40	BOILER HOUSE
45.00	NE	54.00	35.59	107.38	BOILER HOUSE
56.25		54.00	44.87	121.31	BOILER HOUSE
67.50	ENE	54.00	51.07	130.61	BOILER HOUSE
78.75		54.00	51.07	130.61	BOILER HOUSE
90.00	E	38.69	157.24	96.72	EXISTING BLDG.
101.25		38.69	130.04	96.72	EXISTING BLDG.
112.50	ESE	32.30	34.63	80.75	PRECIPITATOR
123.75		-	-	-	-
135.00	SE	-	-	-	-
146.25		-	-	-	-
157.50	SSE	-	-	-	-
168.75		-	-	-	-
180.00	S	-	-	-	-
191.25		-	-	-	-
202.50	SSW	-	-	-	-
213.75		54.00	36.69	109.40	BOILER HOUSE
225.00	SW	54.00	35.59	107.38	BOILER HOUSE
236.25		54.00	44.87	121.31	BOILER HOUSE
247.50	WSW	54.00	51.07	130.61	BOILER HOUSE
258.75		54.00	51.07	130.61	BOILER HOUSE
270.00	W	38.69	157.24	96.72	EXISTING BLDG.
281.25		38.69	130.04	96.72	EXISTING BLDG.
292.50	WNW	32.30	34.63	80.75	PRECIPITATOR
303.75		-	-	-	-
315.00	NW	-	-	-	-
326.25		-	-	-	-
337.50	NNW	-	-	-	-
348.75		-	-	-	-
360.00	N	-	-	-	-

1) Diffusion analysis for groundwater

The Study Team analyzed and studied the advective diffusion of contaminated groundwater from the storage area to the surrounding area. The flow direction, velocity, and flow rate of groundwater are important parameters in analyzing charges in the water quality.

a) Object area

The object area of study is set at about 5-6km from the east side (downstream) of Borsod Power Plant.

b) Object source of pollution

There are a number of storage places for wastes around the Plant, but those of Borsod Power Plant and Borsodchem Co. are principal ones. These principal sources of pollution are regarded as the object sources of pollution. The sources of pollution at Borsod Power Plant are wastewaters from the coal ash sludge storage area and the water treatment plant.

c) Calculation method

i) Darcy's Law and permeability coefficient

The flow rate etc. of groundwater can be found from the Darcy's Law. On an assumption as per Figure 6.5.9, the Darcy's Law is defined as follows.

$$Q = -kA\frac{\Delta h}{\Delta l}$$

where,

A: cross section (m^2)
Δ l: length of sand layer (m)
Q: discharge steadily flowing through the cross section (m^3/s)
Δ h: loss of head (m)
k: permeability coefficient (m^3/s)

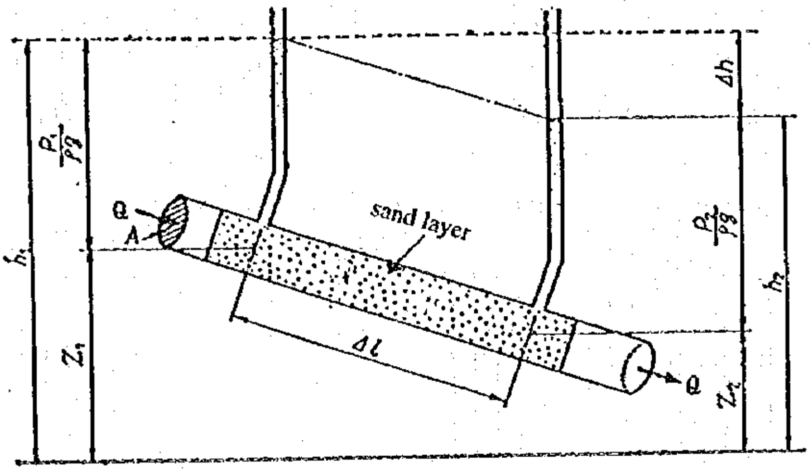


Figure 6.5.9 Darcy's Law

Permeability coefficient K is a constant that can be determined by the grain size of earth and sand, percentage of voids, saturation factor, fluid viscosity, etc. The negative sign indicates that groundwater flows in the direction of lower groundwater level.

Generally, the flow velocity (V) of groundwater is macroscopically defined by the average flow velocity Q/A, but the substantial flow velocity (V_0) has to take the percentage of voids into account and is given by the following formula:

$$V_0 = \frac{V}{\lambda} = -\frac{k}{\lambda} \cdot \frac{\Delta h}{\Delta l} = -\frac{k}{\lambda} \cdot I$$

where I: gradient of groundwater level (Δh／Δl) (m/m)

Moreover, the percentage of voids of earth and sand is expressed by the ratio of the total volume of earth and sand to the total volume of voids, obtained by the following formula.

$$\lambda = \frac{V_v - V_s}{V_v} \times 100(\%) = \frac{S_r - S_0}{S_r} \times 100(\%)$$

where V_v: total volume of earth and sand,

V_s: volume of the substantial particles of earth and sand ,

S_r: true specific gravity of earth and sand,

S_a: virtual specific gravity of earth and sand.

Permeability coefficient

There are various calculation formulas or field measuring methods for finding the permeability coefficient, but the water company ERV Rt. has adopted the permeability coefficient $K=4.86\times10^{-2}$cm/s as the result of investigation.

In the field measuring method, the substantial flow velocity V_0 is found by Tracer Method etc. with the following formula.

$$k=\frac{\lambda_e \cdot v_0}{I}$$

The value λe is shown at values as in Table 6.5.10.

Table 6.5.10 Effective Voids (λe)

Deposit	Voids (%)	Water retentively (%)	Effective voids (%)
Alluvial Gravel	25	10	15
Granul	35	20	15
Sand dune sand	30~35	10~15	20
Silty clay	45~50	30	15~20
Diluvial Sandy	30	10~15	15~20
Sand	35~40	5~10	30
Loam	50~70	30~50	20
Silty clay	50~70	45~60	5~10
Tertiary sandstone	40	5	35

Table 6.5.11 shows the approximate values of permeability coefficient by soil quality. This, however, assumes a roughly even grain of soil; in the case of the gravel stratum as it occurs in the area under review, the particle size on the finer-particle side represents the factor determining the permeability coefficient. $K=4.86\times10^{-2}$cm/s is roughly an adequate value even compared with literature values.

Table 6.5.11 Approximate Value of Permeability Coefficient
[Permeability Coefficient K(cm/s)]

	10^{-9}	10^{-7}	10^{-5}	10^{-3}	10^{-1}	10^{+1}
Evaluation of permeability	Impermeable	very low	low	medium	high	
Grain size D(mm)		0.075	0.425	2.0		
Approx. div.	clay	silt~sandy silt		sand~gravel	clean gravel of soil	

ii) Calculation of flow rate and travel speed of groundwater

The flow rate and travel speed of groundwater was calculated from measured data mainly in regard to the water vein on Sajo River side as follows(assuming the adjective diffusion from Borsod Power Plant facility etc.). Precisely, it is necessary to add the permeated water quantity from the sludge storing area etc., but this was disregarded in view of the current situation of thick sludge technologies currently applied.

Permeability coefficient (k) : 4.86×10^{-4} (m/d)
Gradient of groundwater level (I) : 2×10^{-3} (m/m)
Thickness of permeable layer (m) : 7 (m)
Width of permeable layer (L) : 4000 (m)

and consequently,

Cross section of permeable layer (A)$= m \cdot L = 2.8 \times 10^{4}$ (m^2)
Macroscopic average flow velocity (V)$= k E = 9.72 \times 10^{-7}$ (m/s)
Groundwater flow rate (Q)$= A \cdot V = 2.72 \times 10^{-2}$ (m^3/s)

Since the groundwater vein is mainly composed of gravel layer, on the premise of percentage of voids (λ) of 30%, water retentivity of 10% and effective voids (λe) of 20%, the substantial flow velocity (V_0) results as follows:

$$V_o = \frac{V}{\lambda_e} = 4.86 \times 10^{-6} \ (m/s)$$
$$(\therefore 0.42 m/d)$$

d) Evaluation of analysis results

The following can be said based on the above calculation results.

i) As the yearly average flow of Sajo River is 27.8 m^3/s, it comes to 2,402,000 m^3/d on a daily basis. On the other hand, as the groundwater flow is 2,350 m^3/d accounting for about 1/ 1000 of the flow of Sajo River, this quantity is very small.

ii) The advective speed of groundwater is very slow and it takes about 40 years till it moves from the salt water evaporating plant at Borsodchem Co. to the center of Borsodszirak water service source 1/A. Consequently, even if groundwater pollution counter measures are thoroughly taken, a still longer time will be required till most of the influences of the source of pollution disappear from the water service source.

iii) The groundwater quality will be improved on the whole through the counter measures, but it is also conceivable that its concentration may rise in the future depending on conditions on the spot.

2) Prediction and evaluation of impact

Predictive evaluation was made as to the future groundwater concentration for the case where groundwater pollution counter measures such as impermeable sheet technique were thoroughly taken.

a) Parameters

Prediction items are SO_4^{2-}, Cl^-, Na^+, Ca^{2+} and As.

According to the concentrations distribution of pollutants, As and Ca^{2+} originates in power plant facilities. Most of SO_4^{2-} also originates in the power plant facilities. Meanwhile, sources of Cl^- and Na^+ are found in the water treatment wastewater reservoir as well as in Borsodchem Co. facilities.

b) Setting of predictive calculation conditions

i) Groundwater flow velocity and rate

From the calculation results,

flow velocity : 0.42 m/d (effective voids : 20%)
flow rate : 2,350 m^3/d

ii) Operating time till today of Borsod Power Plant

40 years from 1957

iii) Discharge of coal ash

The amount of fired of coal is estimated by the average yearly values from 1980 through 1990, representing what was burnt up (on a calorific basis) during 40 years.

Table 6.5.12 Combustion of Coal and Discharge of Coal Ash

Item \ Stage	Initial	1980～1990
Coal (t/yr)	(1,301,400)	1,947,000
Calorific v.(MJ/kg)	12.55	8.39
Ash content (%)	21.5	34.7
Coal ash (t/yr)	(279,800)	675,000

Remark ( ) : Estimated value

The quality and fired amount appear to have undergone changes during the 40 years, but the discharge of coal ash is determined at 477,700 t/yr by finding the average from the table.

iv) Background (BG) concentration of groundwater

The average indicators of water quality for the observation wells TM-30 and E-6 which appear not much affected by the influence of industries are regarded as BG concentration.

Component	SO_4^{2-}	Cl^-	Na^+	Ca^{2+}	As
Concentration (mg/l)	92	26	52	94	ND

ND: below detection limit (<0.6 μ g/l)

v) Elution of various components from coal ash

- Elution components are confined to SO_4^{2-} and Ca^{2+}.

- As they occur in extremely limited quantities compared with the Cl^- and Na^+ of wastewater reservoir, Cl^- and Na^+ whose elution is small are considered not to contribute to contaminating the groundwater.

- For the elution quantity of SO_4^{2-}, leakage data (1.59 g/kg Ash) obtained at the initial stage at a thick sludge experimenting place of $100m^2$ which is in operation as of 1997 are applied.

- As for the elution quantity of Ca^{2+}, a Ca^{2+}/SO_4^{2-} ratio (0.31) is obtained from measured data in the observation wells (TT-1, 8～10 and V-2) and the elution is assumed to take place at this ratio.

vi) Leakage ratio from the wastewater of water treatment plant into groundwater

Leakage ratio from the wastewater of water treatment plant into groundwater 50% of wastewater of the water treatment plant is stored at a reservoir. Compositions of the inorganic salts of wastewater are as follows and abt. 1,000t of inorganic salts is stored yearly at the wastewater reservoir where 97～98% of water permeate to contaminate the groundwater.

Table 6.5.13 Ions in Effluent from Water Treatment Plant

Component	Content (%)	Discharge(t/yr)
Cl^-	40	400
SO_4^{2-}	12	120
Na^+	23	230
Ca^{2+}	23	230
Mg^{2+}	1	10
Others	1	10

As Ca is contained as lime sludge also, different from Cl^- and Na^+, it does not permeate through the ground at the above mentioned rate. Consequently, the permeating rate was studied in the water quality of the observation wells (TT-12 and 13) adjacent to the wastewater reservoir.

The content in % of each component is shown in Table 6.5.14 after deducting the BG concentration.

Table 6.5.14 Water Quality of Observation Wells

Component	Concentration (mg/l)	Ratio to Cl (%)	
		waste w.	Obsv. wells
Cl^-	1719	100	100
SO_4^{2-}	808	30	47
Na^+	993	58	58
Ca^{2+}	176	58	10

The ratio of Na^+ to Cl^- is 58% both in the wastewater and observation wells and this demonstrates that it permeates as it is into the groundwater. The ratio of SO_4^{2-} is higher in wastewater (original water) than in the observation wells, but this is considered to be due to the influence from sources such as standby sludge storing places etc. and the 120 t/yr is handled as having few permeated. Meanwhile, most of Ca^{2+} is discharged as lime sludge. Consequently, the ratio in the observation wells is also adopted as representing the permeating ratio.

c) Predictive calculation

As the data used contain a lot of estimated values, predictive calculation parameters are not refined ones. Consequently, the Study Team decided not to use advanced calculation techniques and made calculations with a simple approach tentatively.

i) Total amount of past groundwater contaminations

Total amount of groundwater contaminations with salts etc. due to coal ash and water treatment wastewater from Borsod Power Plant is as shown in Table 6.5.15.

Table 6.5.15 Rough Estimate of Ions in Groundwater Discharged in the Past 40 Years

Component	Coal ash (t)	Water treatment effluent (t)	Total amount (t)
SO_4^{2-}	30,380	4,800	35,180
Cl^-	--	16,000	16,000
Na^+	—	9,200	9,200
Ca^{2+}	9,420	1,600	11,020

For convenience' sake, Cl^- and Na^+ were handled as not contaminating the groundwater.

ii) Total amount of groundwater diluted during 40 years

Groundwater contaminants from the Borsod Power Plant have been diffused and diluted by groundwater vein located mainly on Sajo River water system side. It could be also the effect of dilution by water from wastewater reservoirs and thin sludge (ash/water ratio of abt.1/6). Consequently, in order to get the average of groundwater concentrations for the whole affected area, it is necessary to study the total amount of groundwater.

97～98% of wastewater and sludge water permeates and flows partly into side ditches. A part of the rest evaporates from the neighboring soil, and coal ashes retain roughly the same weight of water. Consequently, the rate substantially flowing into the groundwater at wastewater reservoirs was estimated to come to 70% and that at sludge storage areas to about 60%.

- Groundwater vein on Sajo River side
  4,000 m × 7 m× 0.42 m/d ×365d×40yr×0.2 ≒ 34,339,000 m^3

- Wastewater reservoir
  150,000 m^3/year×0.7 ×40 year = 4,200,000 m^3

- Sludge storage area
  477,700 t/year× 6×0.6 ×40 year ≒ 68,789,000 m^3

- Total amount of diluted water
  1,073,280,000 m^3

iii) Comparison of calculated concentrations of contaminated groundwater with measured concentrations

Results calculated from the total of contaminants and that of groundwater are given in Table 6.5.16.

Table 6.5.16 Comparison of Calculated with Measured Concentrations

Component	Average concentration (mg/l)		Calcul.v./Measured v.
	Calculated v.	Measured v.	
SO_4^{2-}	328	559	0.587
Cl^-	149	310	0.481
Na^+	86	178	0.483
Ca^{2+}	103	170	0.606
As	-	18	-

There was a large difference between calculated values and the measured values obtained from average values of all observation wells. Conceivable causes are as follows.

- Measured values are simple average values of all data. As many of the observation wells are located near the sources, data are more or less overestimated.
- The permeated amount of sludge water etc. into the ground is an estimated value.
- Groundwater flow rate, discharge or available quantity of coal ashes, wastewater quantity, etc. vary by year, but these fluctuations have not been fully taken into account.

Furthermore, from the comparison of calculated and measured values, each of the combinations SO_4^{2-} and Ca^{2+}, and Cl^- and Na^+ are considered to behave similarly in the source and in the ground.

d) Predictive evaluation of environmental influences

Evaluation was made in the cases i) where Borsod Power Plant alone was provided with measures and other sources with none and ii) where Borsodchem Co. additionally was provided with thorough measures.

As seen from the concentration distribution also, Borsod Power Plant facilities are considered to be a source. Consequently, based on Ca^{2+}, as the differences between calculated and measured values were considered to be due to ignoring various conditions, calculated values were corrected to approximate the measured values (Table 6.5.17).

Table 6.5.17 Predictive Calculation of Groundwater Concentrations

Component	Average concentration (mg/l)		
	Corrected calculated v.	Differences from measured v.	Added BG value
SO_4^{2-}	541	18	110
Cl^-	246	64	90
Na^+	142	36	88
Ca^{2+}	170	0	94

The differences from measured values in the table indicate contribution by other sources than Borsod Power Plant facilities. Cl^- and Na^+ concentrations indicates that, in order to preserve the future groundwater quality, consideration should be given also to other sources.

Furthermore, Table 6.5.18 shows the physical and chemical quality standard of drinking water (MSZ 450/1-1989).

Table 6.5.18 Quality Standard of Drinking Water

Item	Qualified value (mg/l)	Permissible limit (mg/l)
SO_4^{2-}	200	300
Cl^-	80	100
Na^+	200	-
As	-	0.05

i) Effect of pollution control measures by Borsod Power Plant

The added BG value in Table 6.5.17 shows the average concentrations all over the groundwater sampling spots (61 points) in a case where groundwater contamination is thoroughly prevented with impermeable sheet technique etc. and the influences from the power plant facilities are thoroughly eliminated after the passage of more than 40 years (supposedly about. 50 years).

By taking sufficient measures for Borsod Power Plant, Ca^{2+} and SO_4^{2-} values can be gradually improved approaching the BG concentration.

Furthermore, as the source of As is confined to power plant facilities, if control measures are taken against contamination by the scattering of gas flue dust or coal ash, its value can be reduced below the detection limit even in the vicinity.

ii) Effect of pollution control measures by both Borsod Power Plant and Borsodchem Co.

The Study Team has been informed that Borsodchem Co. discontinued the use of a saline wastewater evaporating pool system since 1996 which used to be the principal source of contamination and is using anew a wastewater reservoir separated with HDPE.

If hereafter wastewater is stored at this separated evaporating pool only , this will prohibit any more contamination from the salt content.

The Study Team also understands that a plan is under study to thoroughly revive the wastewater reservoir and to prevent groundwater contamination. Detailed information on the method of reviving, make-up of the saline water storing place, total amount of saline water disposed was not provided.

If the plan is implemented and groundwater contamination thoroughly checked now, the water quality will gradually improve and ionic concentrations will approach the BG concentration after the passage of 50 years. This will secure a quality water for a water service source.

The above mentioned predictive evaluation contains various assumptions and is not sufficiently precise, but is supposed to have at least proved that, once groundwater or soil is contaminated, their improvement will take an extremely long time and that it is difficult to thoroughly bring them back to their natural state

(2) Setting of environmental protection goal

Judging from the state of source, most of the groundwater contamination originates in Borsod Power Plant and Borsodchem Co.

When an environmental influence by Borsod Power Plant facilities with heavy metals is considered, except that As occurs at a high value in the vicinity of sludge storage area, no heavy-metal contamination that may injure one's health is observed.

The environmental protection goal must conform to the qualified value and the upper limit (permissible limit) of the national standard (MSZ 450/1-1989) which specifies the physical and chemical quality of drinking water in Hungary as mentioned chapter 6.2. Attainment of the environmental protection goal applies in particular to the tap water wells in Borsodszirak I/A and private wells used at certain parts of Dusnok-puszta even today.

Different from air quality, even if measures were taken, it will be a considerable time before their effect becomes sufficiently obvious. It is difficult to set the year of attainment for the goal, therefore it is important to take actions promptly.

Even if Borsod Power Plant and Borsodchem Co. implemented appropriate groundwater contamination control measures, the Study Team is afraid it will take 30 years to attain the permissible limit for ions in Dusnok-puszta and 40 or even more years, depending on the circumstances, to attain the qualified value.

(3) Proposed measures

1) Outline of measures

Roughly, the following measures are considered.

a) Thick sludge system

b) Impermeable sheet technique

c) Self-repairing sealed water-barring technique by the use of bentonite

d) Excavation of contaminated soil and sealing into impermeable sheet or concrete shut-off tank

e) Vertical sealing works (continuous underground walls made of steel sheet piles, concrete, etc.)

f) Groundwater pumping method (including barrier wells and water injection)

g) Soil coverage, planting (herbaceous plant or trees) or laying Geotextile sheet etc. thereunder to prevent permeation of rain water into the groundwater)

h) Keeping waste acids or alkalis off the waste liquid reservoirs

a) is to alleviate the influence of groundwater pollution through the permeation of water by applying thick sludge instead of thin sludge to the ash transport system, and is nowunder testing at Borsod Power Plant. a)-c) are intended for disposing of coal ash to be discharged hereafter, and d)-g) are approaches for soil and groundwater now being contaminated, which are intended for preventing diffusion of groundwater contamination and for removing or lowering contamination. In connection with the development of Borsod Power Plant, it is necessary to propose optimum alternatives from among these in order to protect the groundwater environment.

And measures that may be helpful for preventing air pollution due to fly ashes are included in these plans.

2) Thick sludge transport system

Borsod Power Plant has adopted a thick sludge transport system from 1996 and is at the same time testing and studying the physical and chemical natures of thick sludge. The principal information that the task force has obtained so far is as follows.

a) The coal ash solidified in a thick sludge test with ashes from the HFBC combustion test conducted at Ajka Power Plant with Lyuko coal proved harmless as a result of an elution test by the Environmental Protection Inspectorate.

b) EKF however demanded to demonstrate the harmlessness over again. Borsod Power Plant in response is now conducting a test on a one-year schedule, using an experimental block of $100m^2$ in size, for physical and chemical properties such as elution status etc.

c) This system is based on an EGI's technique and the Study Team understands that, by piping ash and water at the ratio of 1 to 1.2 and solidifying them at the sludge storage area, they let the water react and be taken inside to cause no more elution nor permeation from the inside and therefore brings no groundwater contamination. In other words, thick sludge has the following advantages.

   - Density of depositing place rises to nearly double the storage capacity in the same space.
   - Water retentivity increases while permeability lowers.
   - Solubility lowers to reduce the elution into groundwater to almost naught.

d) Along with the construction of a newly installed boiler system, suppose a storage area of about 5 ha is provided within the planned coal ash storage area (VIII/1) on a impermeable sheet technique and store 2-3 years stock of sludge there while checking its elution status etc. If its load to the groundwater proves small and not leading to contamination, the Plant thinks to keep on using thick sludge; if it results in problems, it is advised to store the ash by continuing application of the impermeable sheet.

Compared with thin sludge (ash/water ratio of 1:abt. 6), thick sludge has a smaller water content and is capable of alleviating the groundwater contamination. The following problems can be pointed out, however.

- Lyuko coal has a large ash content whose grain is large, and hardly solidifies. It is necessary to test and study over again if it can sufficiently solidify and bring a good result as per information. According to EGI engineers, the ratio of ash and water is very important for the ash to solidify. Even if it can at a beaker test, it is not certain whether the same result can be obtained in a life-size thick sludge system. According to the findings of task force, the mixing ratio of ash and water ranges widely from 1:1.5～ 1:24.0.

- They conducted an elution test to solidified sludge in a laboratory under a Hungarian official method and proved them to be harmless, but in an actual field it will be stored for a long time and may be hit by a record heavy rain. Even then, it is necessary to thoroughly study if there have been any influences on the groundwater.

- As regards the study of thick sludge depositing area now under way in an experimenting block, it is necessary to proceed with the experiment, and fully analyze and evaluate the results. In particular, continuously grasp the quantity and its composition of ash transport water, and leakage water which is discharged from the block, as well as weather conditions such as precipitation from the initial stage, accumulate the findings on Lyuko coal thick sludge and let them be reflected in future measures.

- Borsod Power Plant is planning to utilize the wastewater containing ions as thick sludge transport water in future, but as long as thorough water-barring is unavailable, it is difficult at the present sage to recommend that approach.

The judgment on whether groundwater contamination can be prevented by use of thick sludge must be carefully made with reference to the environmental protection goal and by studying the findings accumulated so far. One should make it a rule to deal with the situation on a safety basis in the case such findings are not sufficiently available.

3) Protection measures for water supply source in Borsodszirak I/A and I

The following two measures are conceivable:

a) Various measures shown in 1), namely, those toward sources (passive and negative measures)

b) Direct measures toward tap water sources (active and positive measures)

From the standpoint of tap water source protection the measures under b) are recommended.

Many other groundwater contamination sources than Borsod Power Plant are found all over the areas under review, and soil and groundwater have already been contaminated. An enormous expense is required for sufficient measures toward these sources and an extremely long time will be required for improving the water quality as mentioned earlier.

Meanwhile, direct measures toward tap water sources are positive measures for the source protection and can display their effect in a short time.

The first method is to take in Bodva river water into the source I/A, develop an underground river water permeating or filtering pond and use it as source.

The second method is to expand the underground permeating pond of the source I. The only defect in this method is its dependence on the water quality of Bodva river. When industrial activities become active in the future, river management in the upper reaches would be a matter of increasing importance.

The Water Management Authority and ERV are planning various measures to protect drinking water sources. The Study Team recommends the use of river water at least till the groundwater quality is improved. Furthermore, shutting off the groundwater vein is conceivable as another positive measure, but since this method takes an enormous cost and entails possible unknown environmental influences due to shutting-off, it is not recommended.

Because of economic depression coupled with an increase in water consumption prices, demand has temporally decreased and has been met by the tap water source I alone, but water shortage is apparently foreseeable in the near future and it is desired to take a prompt action.

6.5.3 Soil

(1) Evaluation of Existing State

The facts that soil contamination by heavy metals has become apparent and that sources of pollution are scattered around in this area have been verified relying on materials collected by the task force. The whole Borsod Power Plant area is a factory district in which places filled up with industrial waste as well as other illegally disposed wastes are found and these have become sources of soil and groundwater contamination. Principal landfills for industrial waste are as shown in Figure 6.5.10.

Landfills for industrial waste are scattered to cause soil contamination with heavy metals, but that originating in Borsod Power Plant is due mainly to As and exerting influences on the neighboring environment. This can be seen from measured data and collected materials of the task force too.

(2) Proposed Measures

When considering the soil contamination originating in Borsod Power Plant, measures can broadly be divided into the following four.

1) Lowering of dust in the gas flue gas (As etc.)

2) Lessening of scattering coal ash from sludge storing areas (As etc.)

3) Lessening of acid/alkali waste liquid permeating into soil (ions)

4) Prevention of soil, water and air pollution due to excavation, and waste during construction concretely

Some concrete measures are as follows:

- Raising flue gas dust collecting efficiency
- Soil coverage, planting and other preventive measures for scattering coal ash
- Thick sludge system and solidification of coal ash
- Conversion of existing boiler fuel to natural gas free from dust (As etc.)
- Not storing waste acid/alkali liquids used for ion exchange resins etc. in the waste reservoir
- Implementation of pollution control measures during construction

In these measures are included cases where soil pollution also leads to groundwater contamination and ones that are related to groundwater pollution measures.

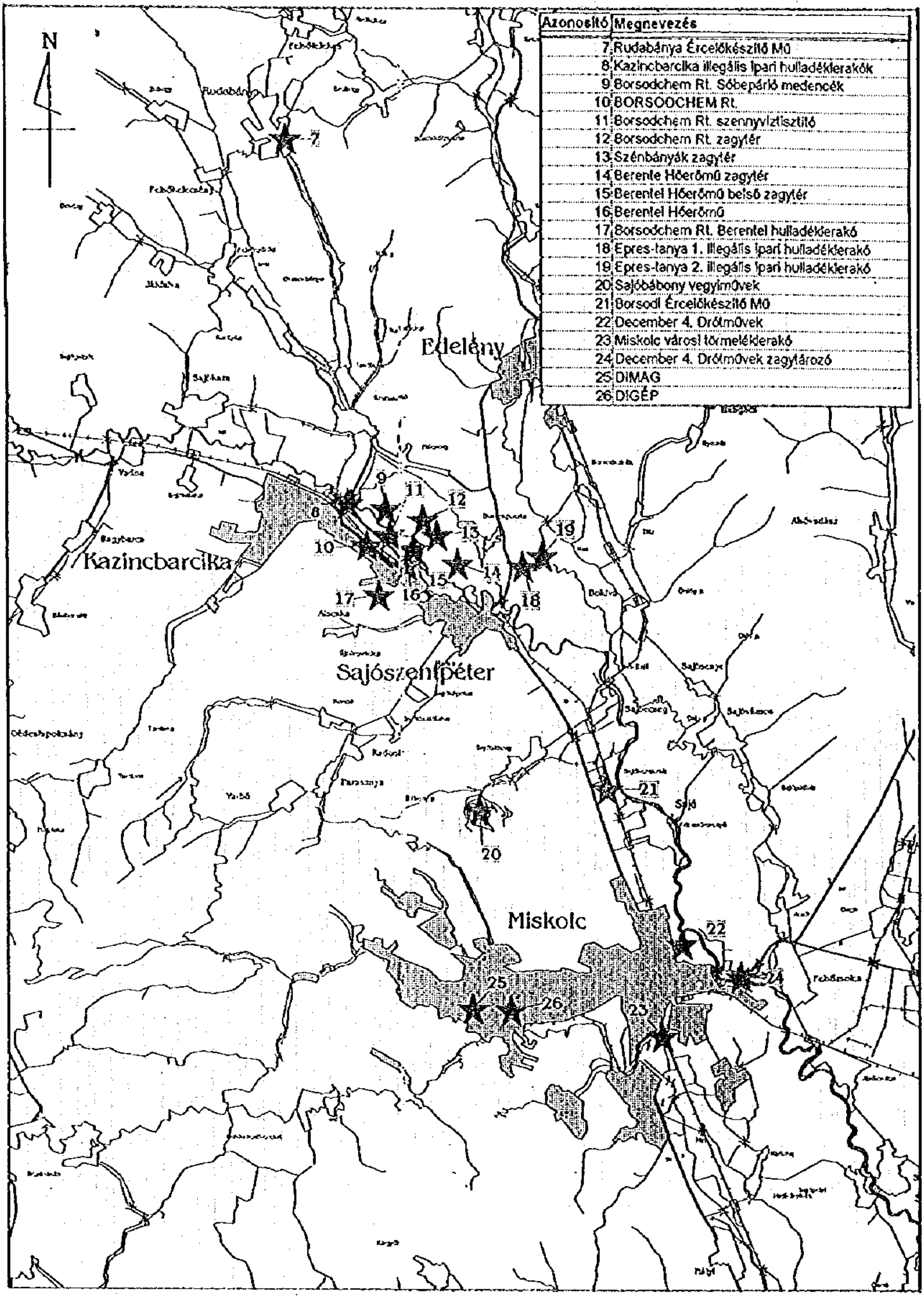


Figure 6.5.10 Main Industrial Waste Disposal Area in the Central Sajo-Valley

(3) Evaluation of environmental impact predictions

The environmental protection goal relates to the environmental protection standard provided in Hungary toward soil and groundwater. Avoidance of environmental influences accompanying the operation of Borsod Power Plant is possible by steadily implementing the above proposed measures 1). When these measures are effected, any further soil contamination is avoidable and natural purifying action will enable gradual recovery of affected areas in the future. The groundwater contaminated mainly by ions, too, will be purified by it combined with other groundwater control measures and recovered to be able to attain the standard level in the long run.

6.5.4 Vegetation

Most of the nature in the central part of Sajo Valley has been affected by Borsod Power Plant etc. and already disappeared. The damage has been to some extent alleviated by now and restoration of vegetation is partly seen in Sajo River.

Now there is a turning point for the natural environment such as vegetation, and it is important that full grasp of the present state and its evaluation are made and appropriate measures for natural protection are implemented.

It is possible to alleviate the environmental impacts by implementing protection measures being planned from which the following effects can be expected:

- Survival and improvement of remaining semi-natural vegetation
- Recovery of lost vegetation

From the standpoint of vegetational protection in the future, it is necessary to try not only to avoid or alleviate environmental impacts but also to create environments.

The following measures are recommended for the protection of the environment.

1) Observation of the emission standards to be enforced from Jan. 1, 2005

2) Prevention of thermal effluent by the adoption of a closed cooling water circulating system

3) Combined use of thick sludge system and impermeable sheet system

4) Creation of an environment with soil coverage and planting for the spent sludge storing areas

5) Development of marshes between Holt-Szuha River and sludge storage areas and creating a wild semi-natural land. This requires a small budget only and has the following advantages.

- Biological mitigation of water pollution becomes possible

- This offers an instance of symbolizing the idea of environmental protection in Borsod Power Plant as well as a means of good corporate PR toward neighboring communities and local public bodies

- They partly serve as a filter for scattering ash

- They represent the expression of the company's will toward natural protection activities

6) Implementation of appropriate measures for handling large amount of wastes accompanying the reconstruction of Borsod Power Plant (It is not to give a new damage to the natural environment.)

6.6 Environmental Protection Measures

6.6.1 Environmental Protection Measures

(1) Air Pollution Control Measures

Major air pollutants emitted from coal-fired power plant are SO_2, NOx and Dust, and the measures against air pollution are needed. Table 6.6.1 summarizes the major measures against air pollutants of SO_2 and NOx.

Measures against SO_2 and NOx are roughly divided into the followings;

- Fluidized bed combustion which enables to reduce both pollutants by itself,
- Flue gas desulfurizer and denitrizer added to PCF,
- As measures against NOx, improvement in combustion method, and
- Fuel conversion from coal to natural gas.

Measures against dust such as fly ash in the exhaust gas emitted from coal-fired power plant are taken by cyclone, EP and bag filter as dry method, and scrubber and wet type EP as wet method. Dry type EP, having characteristics of less pressure loss, wider range of collected particle distribution, high collecting efficiency, high reliability and easy maintenance, is generally applied at coal-fired power plant.

If the effluent velocity from stack is slower than the wind velocity, vertical vortex is generated behind the stack and cavity wake is generated in the leeward region of the structure. These currents produce the downwash of smoke and high-level concentration may occur on the ground. In order to reduce smoke downwash, the stack height should be higher at certain rate than neighboring structures, effluent velocity be higher than 5-6 m/s and the shape of stack be modified. It is possible to predict the concentration caused by downwash with GEP model of EPA in USA.

(2) Water Pollution Control Measures

Measures should be taken against the environmental impact by the intake and discharge of water, the discharge of thermal effluent, the water quality deterioration by the wastewater, and the pollution by the leachate from ash dumping area.

1) Measures against the change of hydrological regime and water level of river caused by the intake and discharge of water by thermal power plant

Table 6.6.1 Measures for Preservation of Air Quality against SO_2 and NOx at Coal-fired Power Plant (1)

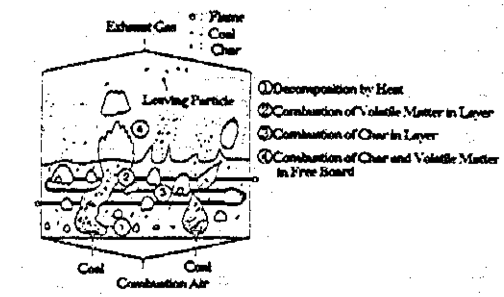
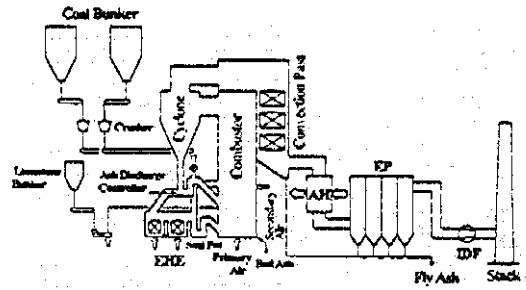
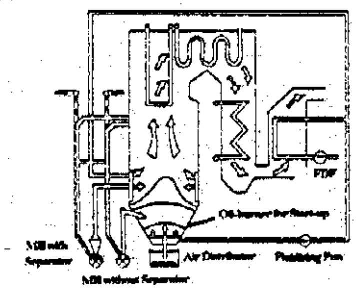
Measures			Reduction effects	Characteristics and Problem	
Combustion Facility	Fluidized Bed Combustion	Common	Effective both for SO_2 and NOx	Fluidized bed boiler fires coarsely crushed coals (less than approx. 25-30 mm) with bed materials (limestone, sand, etc.) in a lower temperature of 800-900 °C, locates the heating surface in the fluidized bed and convection part, and recovers the heat. Compared to the conventional PCF boiler, fluidized bed boiler has the characteristics of the desulfurization in combustion chamber, reduction of NOx generation by two-stage combustion, firing various type of coal including low quality coal, simple mill system, reduction of boiler size and packaged type of boiler.	
		BFBC	Effective both for SO_2 and NOx	When solid particle layer is fluidized by blowing combustion air from the bottom, the burning gas inside the solid particle layer rises, producing babbles. Owing to the movement of babbles upward, the solid particle layer churns by heated gas violently and forms fluidized layer. This BFBC is the initial stage of development of the fluidized bed combustion and the following problems have been experienced; pore closing of coarse grain limestone, low efficiency of limestone utilization owing to the crush of and leaving limestone, and the gypsum decomposition by the heat in a reductive atmosphere.	
		CFBC	Effective both for SO_2 and NOx	In case of BFBC, there exists apparent border plane between fluidized layer and free board. The problem is the low combustion efficiency because of the leaving particle. In case of CFBC, unburned particle leaving combustion chamber is collected by cyclone at the outlet side, recycled into combustion chamber and recirculated repeatedly. The characteristics of CFBC are of higher efficiency of limestone utilization by recirculating the leaving particle and lower generation of SO_2 due to high hold-up of char in combustion chamber and high efficiency of limestone utilization.	
		HFBC	Effective both for SO_2 and NOx	HFB boiler is a kind of BFB boiler. HFB boiler forms fluidized layer at the bottom of PCF boiler by modifying the bottom of existing PCF boiler and equipped with wind box separated into three parts, many nozzles and FDF. Because of the violent circulation of fluidized particle in the combustion chamber, the inside of layer can be maintained a uniform temperature. However, the violent circulation causes erosion of the water tube in the layer. The cost is relatively low, but the desulfurization rate is not so high.	

Table 6.6.1 Measures for Preservation of Air Quality against SO_2 and NOx at Coal-fired Power Plant (2)

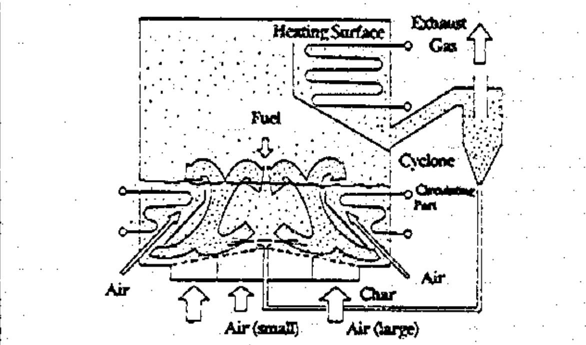
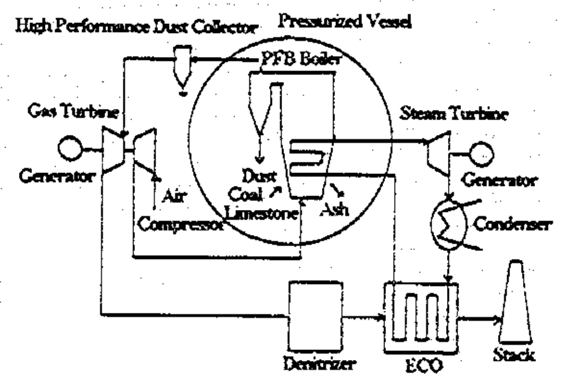
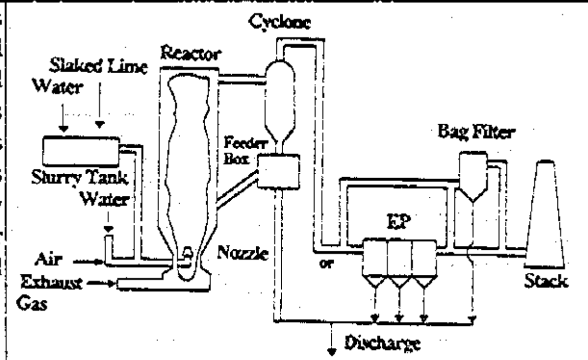
Measures			Reduction effects	Characteristics and Problem	
		ICFB	Effective both for SO_2 and NOx	Fundamentally, ICFB succeeds to the concept of BFB. ICFB has a main combustion chamber and a heat recovering chamber separated by the inclined parting wall in the fluidized layer, uses silica as the inert bed material and arises rotating current in the main combustion chamber and circulating current between the both chambers. It is easier to maintain high layer by applying silica to the bed material, resulting in high limestone utilization. The less fluctuation of the temperature in layer specifies good desulfurization and denitrarion.	
		PFBC	Effective both for SO_2 and NOx, especially excellent for NOx reduction	BFB boiler operated under pressurized condition forms relatively high fluidized bed (the mixture of coal, ash and desulfurizing solvent), reaching 4 meters, fires coal in a temperature of 850 °C and under 6-20 bar, and can reduce SO_2 generated upon the combustion at high efficiency (limestone is used as a solvent and the limestone utilization rate is as high as 80-90 %). PFBC can form combined cycle by operating gas turbine with the exhaust gas, using the power as the source for pressurizing compressor and operating steam turbine with the steam generated by heat exchange in the combustion layer. As the result, the efficiency of power generation attains as high as 39 - 44 %. As the negative side, the generation of SO_3 needs to be suppressed and the initial cost is relatively high.	
FGD	Semi-dry Type	GSA	Very effective for SO_2 reduction	GSA chiefly consists of reactor and cyclone. Slurry limestone is sprayed for the flue gas in the reactor, the limestone is recycled into the reactor after the recovery by cyclone, and recirculated repeatedly. Accordingly, the efficiency of limestone utilization is excellent, thus the desulfurization rate attains 90 % or more. As the water content in the slurry limestone sprayed for the flue gas evaporates instantly, so that the dried by-product is collected by EP or bag filter, of which the latter bag filter results in better desulfurization rate. It is also possible to remove the harmful substances such as HF, HCl, Hg, As, etc.	

Table 6.6.1 Measures for Preservation of Air Quality against SO_2 and NOx at Coal-fired Power Plant (3)

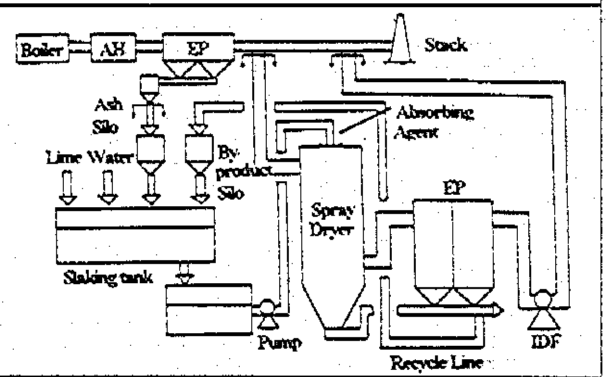
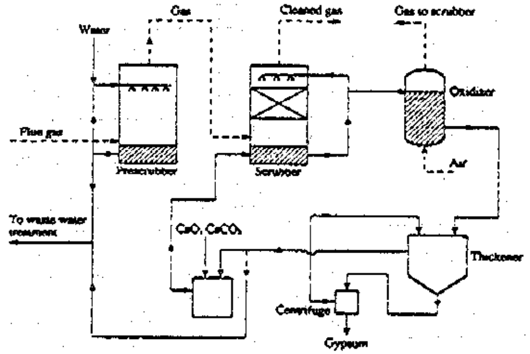
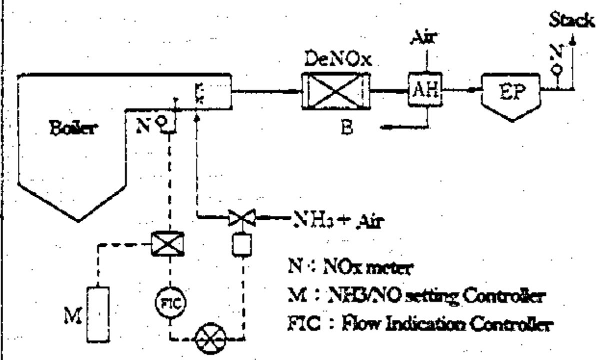
Measures			Reduction effects	Characteristics and Problem	
		Spray Dryer	Effective for SO_2 reduction	The process of spray dryer is that the slaked lime is sprayed into the absorber at the temperature of 150-250 °C, the produced $CaSO_3$ is dried up by the heat of flue gas and reaction heat, and the powdered product is collected by dust collector. This process is rather simple and economical. However, on account of low limestone utilization, the desulfurization performance is a little inferior. In order to raise the desulfurization rate, there are also other processes recycling fly ash and by-product.	
	Wet Type		Very effective for SO_2 reduction	Almost all wet type FGD consists of limestone-gypsum process. The principle is that slurry limestone is sprayed into the exhaust gas and absorbs sulfur oxides. The desulfurization rate attains 90 % or more. This process has been in the steady operation for long term and the by-product gypsum is utilized as a cement mixing agent or plaster board. However, this process needs a large quantity of water for cooling, reheater for the exhaust gas and high-level waste water treatment, so that the cost is relatively high.	
Flue Gas Denitrizer			Very effective for NOx reduction	SCR process, which injects ammonia, reduces and decomposes NOx into N_2 and H_2O by catalyst, is adopted at coal-fired power plant. The characteristics of SCR are no water for the treatment, no by-product and easy operation. However, the problem is that the life span of catalyst is comparatively limited owing to SOx and alkali metal, and that AH is often clogged by ammonium sulfate chemicals which is produced by the reaction of unused ammonia with SO_3 in exhaust gas. In order to extend the life span of catalyst, the development program of the regeneration technology has been now under way, as well as the research for its cost reduction. As the measures for clogging of AH, leaked ammonia is reduced to the lowest level as much as possible.	

Table 6.6.1 Measures for Preservation of Air Quality against SO_2 and NOx at Coal-fired Power Plant (4)

Measures	Reduction effects	Characteristics and Problem
Low-NOx Combustion Technology	Effective for NOx reduction	There are two kinds of NOx generated in boiler. The one is Thermal-NOx, which is produced by high temperature oxidization of N_2 in combustion air, and the other is Fuel-NOx, which is produced by high temperature oxidization of N content in fuel. With regards to the relationships between the amount of NOx produced and the fuel characteristics, in case of Thermal-NOx, the lower volatile matter is, the higher NOx is produced, and in case of Fuel-NOx, the higher N content in fuel is, the more NOx is produced. Coal has the characteristics which tend to produce more NOx in comparison with gas and oil. The amount of NOx , in either case of Thermal-NOx or Fuel-NOx, varies significantly according to the combustion method. Also in case of Fuel-NOx, not every N content in the fuel is converted into NOx, but only 5-25% of N content is converted into NOx. In order to minimize this conversion rate into NOx and also suppress Thermal-NOx production, it is important to reduce the oxidization partial pressure and also lower the flame temperature, and there are following methods; 1) To introduce low-NOx burner which forms compulsorily the reductive atmosphere at the initial stage of combustion by supplying air separately in several parts of burner in order to suppress Fuel-NOx production; 2) To apply two-stage combustion method, which supplies combustion air in two divided stages. Namely, it forms reductive atmosphere at the primary combustion stage and completes the combustion at the secondary stage; 3) To apply EGR, which circulates some parts of exhaust gas in the combustion zone; 4) To apply denitration in combustion chamber by three-stage combustion methods, and others.
Fuel conversion to natural gas	No SO_2 generation	Fuel conversion from coal to clean natural gas. SO_2 is not produced. As the measures against NOx, low-NOx burner and EGR are applied.

As a general rule, thermal power plant needs massive quantity of water for boiler and cooling water for condenser, so that, in case of using water from river with relatively small quantity of water, the environmental impact such as the change of hydrological regime, water level of river and ecosystem may arise. In order to minimize the environmental impact, the measures such as installation of the closed system cooling tower recycling the cooling water by the recirculation should be taken.

2) Measures against thermal effluent

Measures against the thermal effluent are as follows;

a) To install closed system cooling tower which allow to circulate and recycle cooling water in order not to discharge the thermal effluent, and

b) In case thermal effluent is discharged directly, it is important to minimize the environmental impact, by considering the characteristics of surrounding geographical conditions and the regional fishing industry, etc., minimizing the temperature difference between the intake and discharge water, and slowing down the flow speed of intake and discharge water.

Environmental protection measures against the intake water are as follows;

a) To apply bottom water intake to prevent a rise in water temperatures due to the thermal effluent circulated, and

b) To apply a curtain wall to prevent adverse effects on fish and larvae.

Environmental protection measures against the discharge water are as follows;

a) Condenser by-passing (mixed dilution discharge),and
b) Discharging thermal effluent in the water to reduce the dispersion range.

3) Measures against wastewater from power plant

Wastewater from power plant should be properly treated in order to prevent the water pollution. Plant wastewater is treated in an integrated wastewater treatment facility, domestic sewage treated in a purifying tank, leachate from an ash dumping area treated physically and chemically depending on the components.

(3) Solid Waste, Soil Pollution and Groundwater Pollution Control Heasuues

Major waste from coal-fired power plant is as follows;

a) Slag, bed ash and fly ash as combustion residue,

b) Waste acid and waste alkali produced in the regenerating process of ion exchange resin at the water treatment plant, and

c) Sludge, waste oil and other.

If the appropriate management is neglected, waste causes soil pollution and groundwater pollution. Accordingly, measures against waste should fully be taken. Table 6.6.2 presents major measures against soil pollution and groundwater pollution.

6.6.2 Evaluation of Environmental Protection Measures

(1) Evaluation of Air Pollution Control Measures

Major air pollutants emitted from Borsod Power Plant are SO_2, NOx and Dust, and the measures are needed.

The applicability of the measures taken for the preservation of air quality against SO_2 and NOx presented in Section 6.6.1 was examined for Borsod Power Plant. Table 6.6.3 shows the results.

In this Study, the feasibility of CFB and the alternative PCF + FGD for new unit as well as fuel conversion to natural gas and the alternative PCF + FGD for existing units were examined. The following shows the evaluation of each measure taken for the preservation of air quality involving newly installed unit and existing units.

1) New unit

When CFB is compared to the alternative PCF + FGD,

(a) The former enables desulfurization in combustion chamber and low NOx in the combustion facility itself. That means CFB does not require other auxiliary facilities for the preservation of air quality.

Table 6.6.2 Major Measures against Soil and Groundwater Pollution (1)

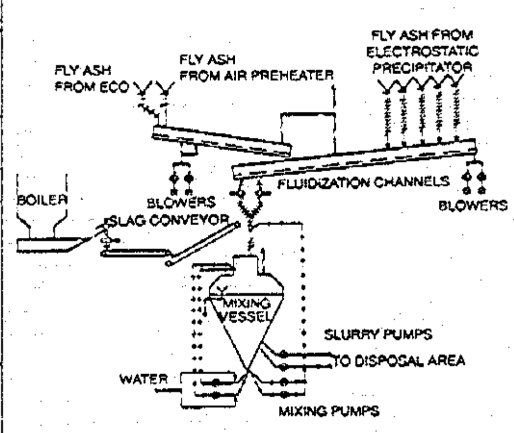
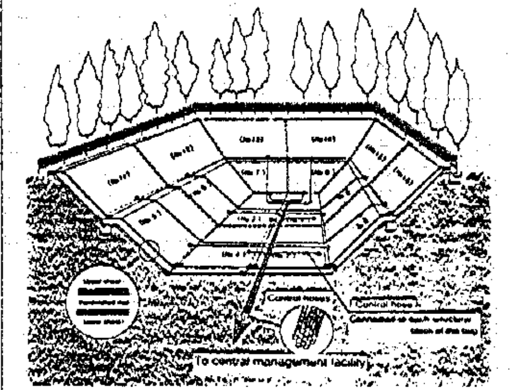
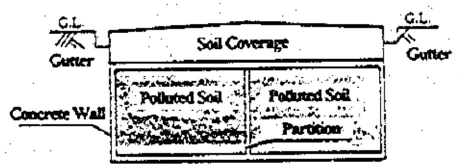
Measures	Contents of measures	Characteristics and problem	
Thick sludge technology	Decreasing leachate and reducing ground water pollution	A massive combustion residue, which consists of slag, bed ash and fly ash, is produced at coal-fired power plant. Until recently, the most common method of the transportation has been thin sludge technology, in which the solid and water is mixed at a ratio of 1:2 up to 1:15 and transported through pressurized pipeline to the dumping area. However, this method causes the following problems: 1) Large dumping area is needed. 2) Transport water elutes heavy metals and ion family contained in ash, and the polluted water infiltrates and causes the ground water pollution. 3) Dust dispersion by wind from the dried dumping area. Therefore, in Hungary, the research and development of the thick sludge technology has been underway as the measures against mentioned above. Thick sludge technology decreases the quantity of water mixed with ash and solidifies the ash by chemical bond, resulting in the reduction of leachate and ground water pollution. But this technology has been now on the stage of development, like the mixed ratio of water and ash varies widely case by case. Therefore, it is recommended to apply this technology together with other developed technology.	
Sealing works using impermeable sheet	Intercepting leachate with impermeable sheet and preventing from ground water pollution	Polluted soil is contained within the water intercepting basin with impermeable sheet. As the impermeable sheet, synthetic rubber and plastic sheet of 1 mm or more, and asphalt sheet of 3 mm or more in thickness is generally applied. Impermeable sheet made of HDPE as a material and double sheets as a method of construction has currently been in use. Though the sheet is complete in impermeability, it may cause rupture or detach at the joints. Accordingly, upon the construction, removing big pebbles and projections, and placing impermeable sheet on a flat and sufficiently smoothly-hardened soil, are indispensable. According to the conditions, it is necessary to install drain pipe on the sheet in order to detect and drain leachate.	
Containment into sealed concrete reservoir	Isolating waste and preventing from ground water pollution	In case harmful substances such as Hg, Cd, Pb, Cr^{6+}, As, CN, PCB, etc. are contained in combustion residue, dust, sludge and slag exceeding standards, the waste should be sealed in concrete reservoir in order to isolate waste from the surrounding. Upon the construction, according to the conditions, drains, reservoirs and others for collecting rain and other water should be provided in and around the area of the concrete reservoir in order to keep rain water off. The standards for the water-tightness, durability and safety of the structure provided by the relevant law and regulation should be met.	

Table 6.6.2 Major Measures against Soil and Groundwater Pollution (2)

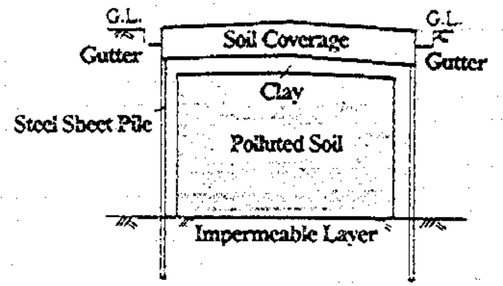
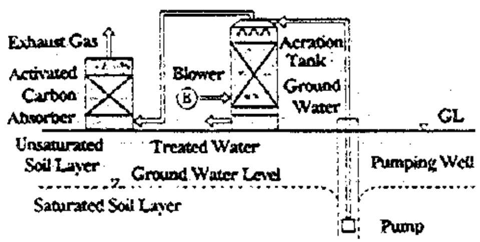
Measures	Contents of measures	Characteristics and problem
Containment by vertical sealing works	Isolating waste and preventing from ground water pollution	There are two kinds of construction method; a) Use of both steel sheet pile and clay. b) Use of both ground continuous concrete wall and impermeable sheet. Above mentioned a) is to isolate waste using steel sheet pile and clay as a water intercepting materiel and to contain the polluted soil in the basin. Steel sheet pile construction method is especially effective for the soft layer with clay and silt, loose sand, and sand mixed small pebbles, of the alluvial soil. b) is to isolate waste using ground continuous concrete wall and impermeable sheet and to contain the polluted soil in the basin.  Sealing Works by both Steel Sheet Pile and Clay
Soil excavation	Removal of pollutants	Pollutants are removed and recovered by excavating the polluted soil and drying the soil by wind or heating the soil in the area or out of the area. If the exact area for the excavation is decided, this method is effective and can be applied in a relatively short period.
Impermeable wall	Preventing polluted ground water from dispersing	In order to prevent highly polluted soil and ground water from dispersing, the area is enclosed by water impermeable wall such as steel sheet pile. The condition of stratum at the spot and surrounding areas, the distribution of aquifer, and ground water current should be taken into account, and this impermeable wall be applied to the depth of impermeable stratum. As the structure of impermeable wall, there are some kinds such as steel sheet pile, continuous ground wall, cement and mortar wall, whose application should be decided according to the coefficient of water intercepting effectiveness, characteristics of stratum and the depth to be applied.
Ground water pumping	Removing pollutants from polluted ground water	This method is to remove and recover pollutants from the polluted ground water by pumping. Even a dense liquid pollutants, staying over a impermeable layer (clay layer) situated under part of saturated soil layer, occasionally is pumped by the appropriate installation and with the conditions of ground water current. Occasionally, the pumping low polluted ground water is impractical. However, this pumping ensures to remove and recover the pollutants. Pumping well for polluted ground water also plays a role as a barrier well to prevent the polluted ground water from dispersing. In order to treat the polluted groundwater pumped, there are two methods, one is aeration method and the other is absorption with activated carbon. The latter is more common in use for the treatment of highly polluted ground water. 

Table 6.6.2 Major Measures against Soil and Groundwater Pollution (3)

Measures	Contents of measures	Characteristics and problem
Soil coverage and planting	Preventing pollutants from dispersing	Unpolluted and appropriate soil should be used for the coverage and planting. The thickness of covering soil is generally 50-60 cm or more. However, 1.5-2 m soil coverage in thickness is needed, depending on the kind and specific planting. In case covering soil over the concrete reservoir or sealing works, slope with some degree should be provided in order to drain out rain water. There are two kinds of planting, one is by grasses and the other is by plants. In case of urgent planting of trees and plants, grass seeding, mat planting and lawn planting are most common.
Handling of waste acid and waste alkali	Preventing salt from infiltrating into ground	All waste acid such as waste sulfuric acid, waste hydrochloric acid, organic waste acid, etc., and all waste alkali such as waste soda, metal liquid soaps, etc., should not be disposed in the dumping area, but neutralized in a neutralization tank and then be discharged into waters for public use.
Others	Preventing pollutants from dispersing	Water sprinkling, covering with water proof sheet and the like, and wind break netting
	Selling to recycling dealer	Coal cleaning sludge, waste oil and the like which are able to recycle should be sold proper dealer.
	Utilizing proper dealer	Harmful substances should be handled by proper dealer with permission of transportation, treatment and harmlessness.

Table 6.6.3 Applicability of the Measures taken for Preservation of Air Quality against SO_2 and NOx to Borsod Power Plant

Measure		New or Existing	Possibility	Ground
Combustion facility				
Fluidized bed	BFBC	New	△	Fluidized bed combustion technology has been developing from BFBC to other various ones at present. It is difficult to apply BFBC, one step older technology, to Borsod Power Plant from the principle that the relevant technology should be accumulated in Hungary.
	CFBC	New	◎	CFBC enables to take measures simultaneously against SO_2 and NOx, and is in well-developed stage. For Hungary without any experience of CFBC, this combustion technology that can be accumulated in this country is the optimum.
	ICFB	New	×	ICFB with an evaporating capacity of 70 t/h developed in 1987 is being used for existing industrial boilers. The application of ICFB is technically impossible because the evaporating capacity required for Borsod Power Plant is in a different far larger scale reaching 460 t/h.
	PFBC	New	×	PFBC is of the most up-to-date technology but involves large initial costs, and not applicable to Borsod Power Plant.
	HFBC	New	×	HFBC has been listed as a candidate for improving the existing units at Borsod Power Plant, but it is not applicable to Borsod Power Plant because HFBC cannot meet the emission standards to be applied after 2005.
FGD				
Semi-dry type	GSA	Existing	○	GSA provides an excellent performance among semi-dry type FGD technically, spatially and economically. The applicability as a measure against SO_2 to Borsod Power Plant depends on other conditions.
	Spray dryer	Existing	×	As far as the introduction of semi-dry type FGD is concerned, GSA provides better performance than that of spray dryer.
Wet type		New	△	It is desirable to take other measures against SO_2 in order to minimize the intake of water from Sajó River.
Flue gas denitrizer		Both	×	In addition to flue gas denitration, other measures should be taken against SO_2. Flue gas denitration is impossible also from the viewpoint of the costs required.
Low NOx combustion technology		Existing	◎	When the fuel of existing units are converted to natural gas, the application of low NOx burner and EGR is conceivable as a measure taken against NOx.
Fuel conversion to natural gas		Existing	◎	It is fully possible to use natural gas for the existing units at Borsod Power Plant judging from the situation of natural gas supplied. The above mentioned low NOx combustion technology is used at the same time.

Legends: Applicability to Borsod Power Plant, ◎ very potential, ○ potential, △ difficult, × impossible

(b) Wet type desulfurizer uses a large amount of water for treatment including cooling water. Further demand in the amount of water taken from Sajó River becomes necessary for FGD in addition the cooling water for new unit. In particular, in summer when the flow extremely decreases, such demand in the amount of water taken from Sajó River seriously impacts the environment and ecosystem.

(c) Wet type FGD requires wastewater treatment on a higher level after desulfurization.

Based on the above reasons, CFB is considered to have less impact to the environment in the case of Borsod Power Plant. Thus, CFB enables a decrease in SO_2 emission through desulfurization in combustion chamber and control in the generation of NOx. Therefore, CFB is recommendable for the measures against SO_2 and NOx.

For dust collection, dry type EP is installed.

As the result of application of CFB, the concentration of major air pollutants at the normal conditions and 6 % of O_2 concentration in exhaust gas will be as follows and satisfy the emission standards to be introduced in 2005.

SO_2 : Max. 400 mg/Nm^3
NOx : Max. 200 mg/Nm^3
CO : Max. 250 mg/Nm^3
Dust : Max. 50 mg/Nm^3

The height of stack should be 130 m as a measure taken against downwash.

2) Existing units

When fuel conversion to natural gas is compared to the alternative PCF + GSA,

(a) GSA can minimize the intake from Sajó River to be used as water for lime slurry by utilizing turbine cooling water. However, it is necessary to consider the handling and transport of the waste produced by reacting with SO_2.

(b) Application of low NOx burner and EGR as the measures against NOx involved with fuel conversion to natural gas enables to satisfy the emission standards.

When selecting the above mentioned a) or b), the Study Team recommends selecting the fuel conversion to natural, taking into consideration not only the environment but also the fuel availability, the economy and the actual situation in Hungary.

Fuel conversion to natural gas does not involve any problem caused by dust. However, as a remarkable amount of dust emitted from the stacks has been identified during the Site Works in Hungary, it is necessary to improve the performance of existing EP for the period of time before existing units are improved.

As the result of modernization of existing uints, the concentration of major air pollutants at the normal conditions and 3 % of O_2 concentration in exhaust gas will be as follows and satisfy the emission standards to be introduced in 2005.

SO_2	:	Max.	35 mg/Nm^3
NOx	:	Max.	200 mg/Nm^3
CO	:	Max.	100 mg/Nm^3
Dust	:	Max.	5 mg/Nm^3

(2) Evaluation of Water Pollution Control Meanness

Possible environmental impacts by the effluent discharged from Borsod Power Plant are as follows:

- Changes in hydrological regimes and water level caused by a large amount of the intake from Sajó River including the cooling water,
- Rise in water temperature caused by the thermal effluent, and
- Water pollution by the effluent from Borsod Power Plant and the leachate from the sludge storage area flowing into rivers.

Necessary measures should be taken against impacts mentioned above.

It is important to minimize the intake from Sajó River the flow of which decreases extremely in summer.

The new unit to be operated in the condensing mode requires a cooling facility. If the cooling water is fully taken in from Sajó River and the thermal effluent is discharged, the hydrological regimes, water level, water temperature and ecosystem in Sajó River will be seriously affected therewith. In order to minimize the impacts of the intake from Sajó River and the thermal effluent, closed system cooling tower will be installed where the water is recycled for use. Thus, the impacts on the ecosystem in Sajó River will be reduced. The existing units operated in the mode of back pressure extraction are free from being affected by thermal effluent.

The oil content discharged from garages and car washes is being collected by oil trap pits, but the capacity should be expanded.

For the leachate flowing into the rivers from the sludge storage area, impermeable sheet of sealing works should be laid at the bottom of sludge storage area and the leachate collected by recovery piping should be recycled for sludge transportation.

(3) Evaluation of Solid Waste, Soil Pollution and Groundwater Pollution Control Measures

Main waste produced from Borsod Power Plant at present or involved with future expansion is combustion residue such as slag, bed ash and fly ash, waste acid and waste alkali produced in the regenerating process of ion exchange resin for the treatment of boiler feed water, and coal washing sludge arising from coal washing plant. Coal washing sludge will not arise after the closing of coal washing plant planned within 1997. Figure 6.6.1 shows each block of sludge storage area where the above mentioned waste is stored.

Concerning the measures taken against the combustion residue with the maximum amount of generation, the applicability of the measures taken for the preservation of soil and groundwater to Borsod Power Plant was examined. Table 6.6.4 shows the results.

1) Sealing works using impermeable sheet together with thick sludge technology

There are two types of coal ash produced from existing PCF boilers; one is slag discharged from the bottom of boilers, and the other is fly ash discharged from ECO and EP. On the other hand, bed ash and fly ash will be discharged from new CFB boiler. Characteristics of ash from CFB boiler are quite different from that from PCF boilers due to the different combustion temperature. In addition, the composition of ash from CFB boiler is also quite different from that from PCF boilers, because limestone as a desulfurization solvent is fed into the combustion chamber. The bed ash to be discharged from CFB boiler contains $CaSO_4$ (gypsum), $CaSO_3$ and unreacted CaO.

Table 6.6.4 Applicability of the Measures for Preservation of Soil and Groundwater

Measure	Possibility	Ground
Thick sludge technology	◎	Transportation using thick sludge technology is superior to that using thin sludge technology from the view point of both environment and cost. However, the former in the course of progress requires other preservation measures used together.
Sealing works using impermeable sheet	◎	These sealing works prevents groundwater pollution by thoroughly isolating the leachate coming from sludge storage area using impermeable sheet, and are fully applicable in Hungary.
Containment into sealed concrete reservoirs	×	This containment is applicable to harmful substances. In June 1997, in Hungary, Waste Qualification Committee concluded that solidified ash was not harmful substances. In this case, such containment will involve excessive facilities. In addition, it is actually impossible to contain the sludge into sealed concrete reservoirs due to large area used for sludge storage area.
Containment by vertical sealing works	×	It is practically impossible to implement sealing works in the whole surroundings due to large sludge storage area.
Soil excavation	×	Soil excavation technique is not applicable due to large sludge storage area. However, this technique is effective as the measure taken against local waste and soil pollution.
Impermeable wall	×	Impermeable wall is used for insulate groundwater pollution, but it is necessary to take into consideration the secondary influences when the groundwater is intercepted. If impermeable wall is constructed upstream the water source I, harmful substances may elute out of the waste dumped upstream by Borsodchem Co. due to the dammed up groundwater.
Groundwater pumping	×	The application of groundwater pumping is difficult because the concentration of groundwater pollution is low and widespread.
Soil coverage and planting	◎	Soil coverage and planting are effective as measures for preventing the scattering of coal ash and coal grading sludge in the sludge storage area.

Legends: Applicability to Borsod Power Plant, ◎ very potential, ○ potential, △ difficult, × impossible

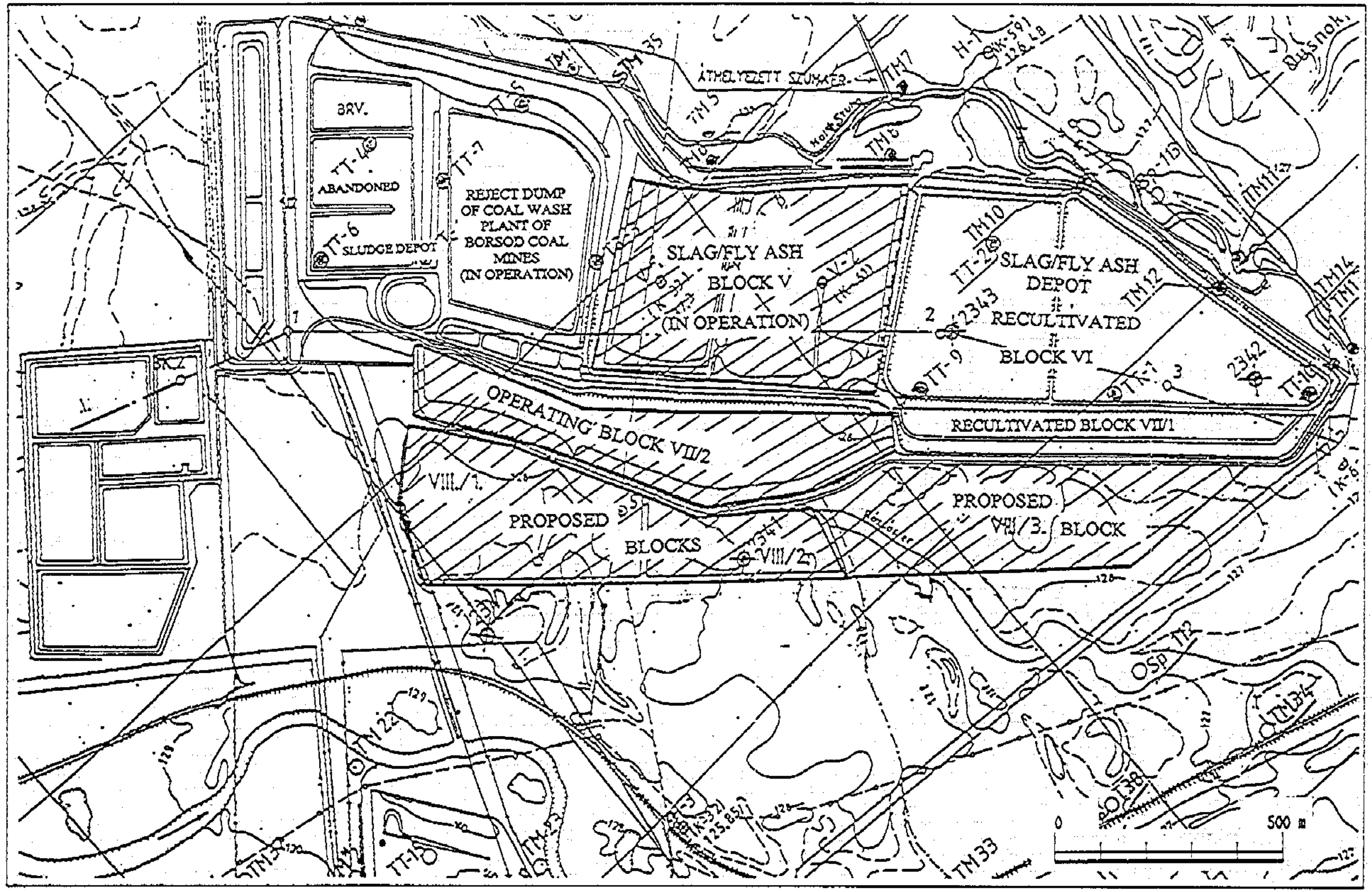


Figure 6.6.1 Layout of Sludge Storage Area

In Hungary, there has been no experience of operating CFB boilers, and knowledge regarding the composition and theological characteristics of bed ash is not sufficient. A combustion experiment was carried out using HFB boiler with Lyuko coal at Ajka Power Plant. At this time, elution test was carried out using the combustion residue. According to the Ruling dated September 1, 1996, by EKF which is the regulatory authority controlling Borsod Power Plant, Waste Qualification Committee concluded that solidified ash was not harmful substances. However, EKF demanded Borsod Power Plant to repeat the test for the purpose of understanding the influences of weather conditions, the amount of ash produced under the condition of operation, and the physical properties. Simultaneously, EKF demonstrated clearly the standpoint that it is allowed to dump solidified ash only in the area where technical protection has been provided and the test has been carried out.

For new sludge storage area, EKF and North Hungarian Water Management Directorate have given the instruction based on the following three conditions.

(a) The maximum volume of water that can infiltrate into the ground from a 32 ha sludge storage area shall be 10 m^3/day.
(b) Impermeable sheet shall be laid at the bottom of sludge storage area.
(c) The maximum height of piled waste shall be 14 m.

The term of validity of instruction mentioned above is two years, and it is more than two years since Borsod Power Plant has obtained the approval for use. The approval should be renewed.

At present, Borsod Power Plant is transporting the combustion residue of PCF using thick sludge technology in lieu of thin sludge technology. For examining the situation of transporting thick sludge to sludge storage area, the Study Team sampled the sludge at the outlet of transport pipes during each Site Work I, II and III. The mixing ratios of solid and water in sludge are as follows.

Site Work I	1 : 5-7
Site Work II	1 : 2
Site Work III	1 : 24

As mentioned above, remarkable fluctuations in mixing ratios were found. Thus, the Study Team continuously sampled approx. every 30 minutes during 13:00 to 17:00 on February 27 to understand secular changes. Table 6.6.5 shows the results.

Table 6.6.5 Secular Changes of Mixing Ratio

	Time	Mixing ratio of solid and water
1	13:05	1:8
2	13:21	1:1.9
3	13:52	1:1.5
4	14:13	1:1.5
5	14:33	1:1.5
6	14:53	1:2.3
7	16:13	1:1.6
8	16:33	1:1.9
9	16:53	1:1.5

Based on the above mentioned data, it is possible to transport the combustion residue at a mixing ratio of approx. 1 : 1.5, but the fluctuations remarkably depend on time. It may be said that thin sludge in place of thick sludge is transported in many cases.

In response to the requirements indicated in the above mentioned EKF's Ruling, Borsod Power Plant implemented leachate infiltration experiments in thick sludge, using a 100 m^2 experimental area prepared in a sludge storage area with double sheets (HDPE is used for the lower layer, and a protection sheet is laid thereon.). The following shows the outline.

(a) Objectives of experiment

The short-term, medium-term and long-term influences of thick sludge on the environment is examined including the behavior and conditions of transport water in the process where thick sludge is deposited, the behavior and conditions of flooded water on the surface layer after sludge is solidified, and the influences of rainwater and freezing, based on laboratory experiments and those carried out in experimental block prepared in a sludge storage area.

(b) Laboratory test

The knowledge in relation to the following items is obtained using sludge prepared for transport.

- Sludge density
- Mixing ratio of solid and water
- Evaporation loss of water
- Infiltration coefficient
- Component analysis
- Others

(c) Block experiment in sludge storage area

A 100 m^2 experimental area is prepared in a sludge storage area. Impermeable sheet are laid at the bottom and the drain pipe is installed to collect the leachate. The following items are examined in relation to the leachate and sludge.

- Secular changes in the amount of leachate
- Infiltration of flooded water
- Influence of rainwater and freezing
- Measuring the temperature to estimate evaporation
- Sludge density
- Water holding and water loss
- Mixing ratio of solid and water
- Infiltration coefficient
- Component analysis
- Others

(d) Schedule

Experiments classified into three groups, short-term, medium-term and long-term experiments, are implemented.

i) Short-term test

- In First Period, deposition of sludge up to a height of 50 cm, flooding up to a height of 5-10 cm, and examination of the volume and components of leachate, and the components of sludge

- In Second Period, deposition of the sludge up to a height of 100 cm, flooding up to a height of 5-10 cm, and examination of the volume and components of leachate, and the components of sludge

ii) Medium-term test

- In First Period, observation of the amount of precipitation and atmospheric temperature, and examination of the influences

- In Second Period, deposition of the sludge up to a height of 150 cm, flooding up to a height of 5-10 cm, and examination of the volume and components of leachate, and the components of sludge

iii) Long-term test

Measurement of the water level and quality in monitoring wells

Figure 6.6.2 shows the experimental area laid by impermeable sheet.

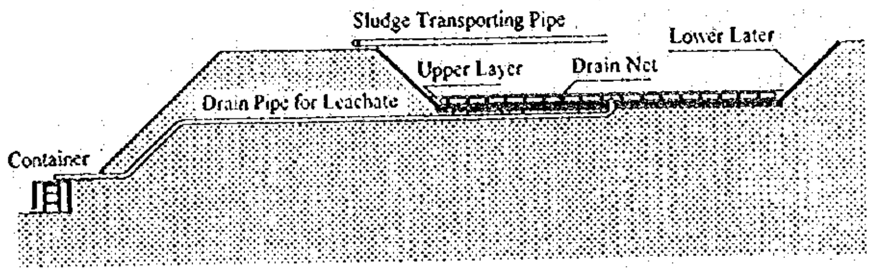


Figure 6.6.2 Experimental Area Laid by Impermeable Sheet

Out of the above mentioned experiments, the short-term test in First Period was already performed in December 1996. The schedule of the whole experiments including the summarization covering about a year will be completed in March 1998.

Table 6.6.6 shows the results of analyzing the components of thick sludge and leachate presented by Borsod Power Plant during the period of Site Work III.

Table 6.6.6 Results of Analyzing the Components of Thick Sludge and Leachate

	SO_4^{2-} (mg/l)	Soluble substances(mg/l)	pH	Hardness (mg/l)**	Conductivity
Thick sludge before transport (1 sample)	1690	4026	12.0	1000	-
Thick sludge at outlet of transport pipe (2 samples)	1352	2500	7.8*	-	-
Leachate	1299	2168	8.9*	-	-

* According to Borsod Power Plant, the measurements were faulty.

** Values from other experiments where the ash consisting of EP, ECO and slag were mixed for use. German hardness is used. The mixing ratio of sludge (dry) and water was 1 kg and 6 kg. Mixing time was three hours.

Table 6.6.7 shows the mixing ratio of water and ash.

Table 6.6.7 Mixing ratios of water and ash

	Mixing ratio	Ash (dry)*	Water
1	1.277 kg/l	578 g	699 g
2	1.290 kg/l	580 g	710 g

* Ash was dried at 100°C. Some water content remains.

The results of the above mentioned experiment only showing the concentration of sludge and leachate without the amount of leachate does not clarify the whole amount of contaminants. Borsod Power Plant regards this experiment as that to be performed throughout a year, but the number of analytical items concerning the concentration is insufficient in comparison with the contents of the First Period of Short-term test, and the details of the experiment also seem to be dissociated from the plan. Thus, it may be said that the results of the experiment performed in December, 1996 are insufficient.

The combustion residue to be discharged from new CFB unit at Borsod Power Plant is bed ash and fly ash. As mentioned above, the components of the combustion residue are different from those of the slag and fly ash arising from PCF. Therefore, it is expected that the behavior and characteristics of the leachate from the sludge remarkably differ from those in the knowledge obtained from the experiment so far. In addition, the existing units are planned to convert the fuel from coal to natural gas. Consequently, the transportation of the combustion residue from PCF using thick sludge technology will be until the modernization of existing units, only.

According to EKF Ruling, Borsod Power Plant plans to transport bed ash and fly ash from new CFB unit with thick sludge technology and lay impermeable sheet at the bottom of sludge storage area. However, the impermeable sheet is only 5 ha equivalent to the amount of sludge stored approx. for two years, and Borsod Power Plant has an idea for accumulating the knowledge regarding the leachate through the sludge and not laying the sheet any longer thereafter.

However, as mentioned above, it is considered that the transport with thick sludge technology has not reached yet the level of technological completion due to the following reasons;

(a) The mixing ratio of water and ash is always fluctuating, and

(b) The rheological characteristics and solidifying process of the ash arising from PCF are different compared to those from CFB.

In order not to cause further groundwater pollution, it is recommendable to apply both the thick sludge technology and impermeable sheet at all bottom of the sludge storage area.

For the leachate through sludge, it is considered to collect it with drain pipes and recycle it as transport water utilizing the existing piping running from sludge storage area to Borsod Power Plant.

The followings show the specifications of impermeable sheet with recovery system of sludge leachate.

- Lower layer : HDPE with a thickness of 1.5 mm
- Medium layer : PE drain net
- Upper layer : Protection layer with 200 g/m^2
- Area : 34.2 ha
- Pump : V = 50 m^3/h, P = 6 kW
- Sump for leachate : 4 m^3 x 5
- Piping : Utilization of existing piping from sludge storage area to Borsod Power Plant

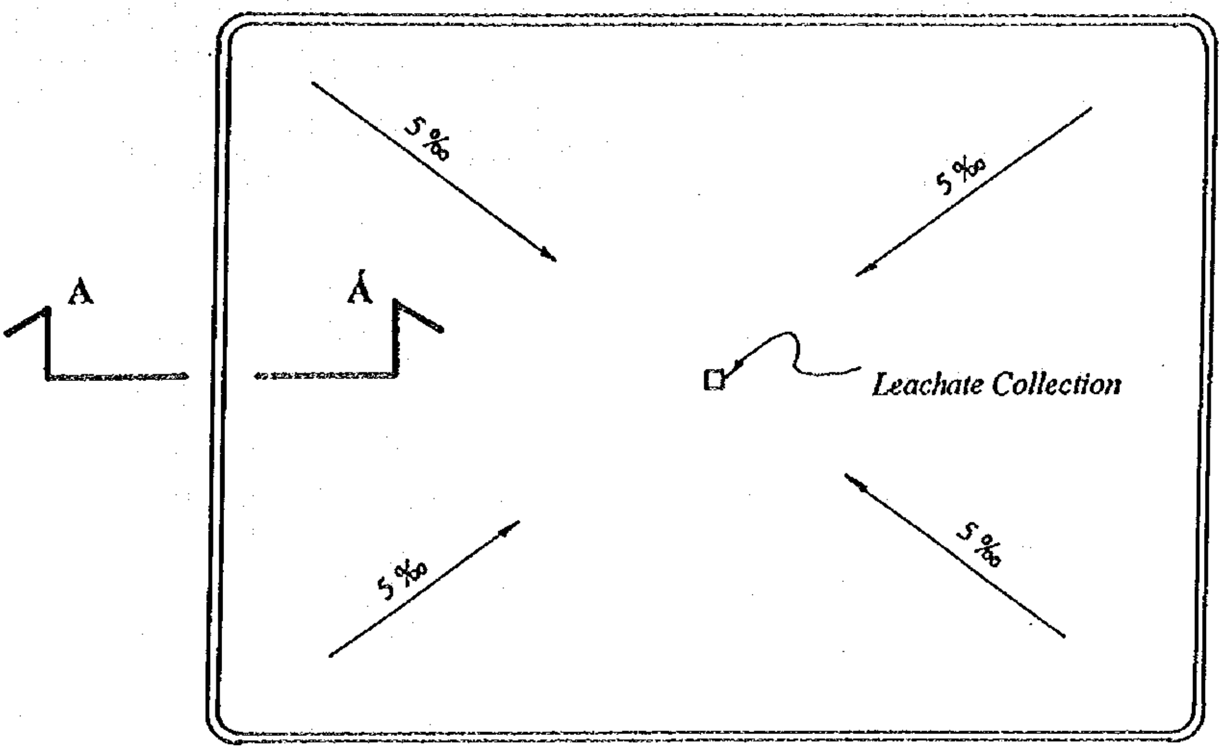
Figure 6.6.3 shows a plan of impermeable sheet to be laid at the bottom of the sludge storage area.

In order to prevent from further groundwater pollution, sludge from the existing units will be received in the block with impermeable sheet laid for the new CFB unit. Accordingly, the time for laying the impermeable sheet will be in 1997.

Related to the construction method, it is desirable to lay the impermeable sheet every approx. 5 to 6 ha equivalent to approx. 6 years not all 34.2 ha, in order to prevent the impermeable sheet from deteriorating due to ultraviolet rays or ozone. The bank side laying the impermeable sheet should be protected so as not to be exposed to air due to the same reason mentioned above.

2) Treatment waste acid and waste alkali

At present, the waste acid and waste alkali produced in the regenerating process of ion exchange resin used for treating the boiler feed water is disposed at the dumping area. However, the salts produced by neutralization infiltrate into the ground and have caused groundwater pollution. Borsod Power Plant is also examining the possibility of using waste acid and waste alkali as the transport water for thick sludge in future.



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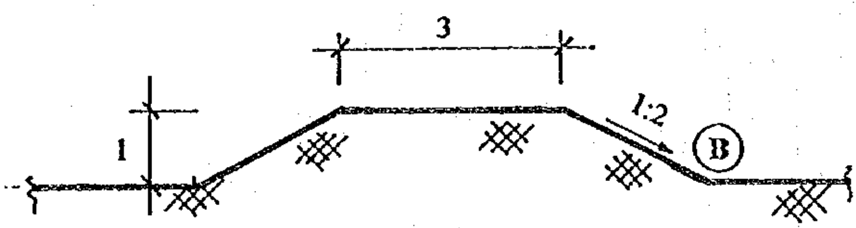
Cross Section A-A'



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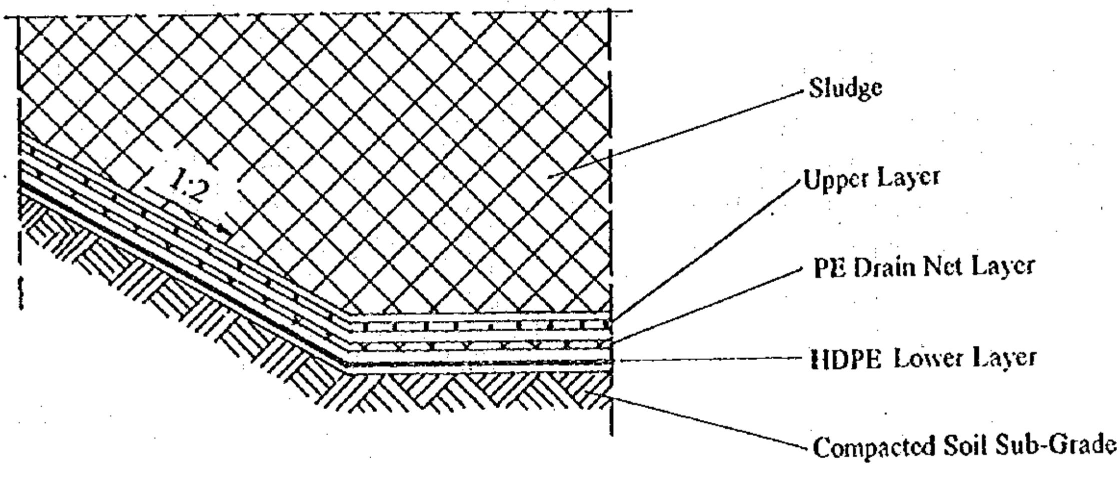


Figure 6.6.3 Plan of Laying Impermeable Sheet (Source: COMCO)

If the pH values tend to be acid or alkaline without perfect neutralization, the harmful substances such as heavy metals contained in the sludge may elute with a higher possibility. In addition, for manufacturing the impermeable sheet to be laid, acid resistance and alkali resistance are taken into consideration to a certain extent. However, if the impermeable sheet is contacted by acid or alkali for a long time, the deterioration may get accelerated.

EKF Ruling 8 has laid down the prohibition of mixing waste acid and waste alkali produced in the regenerating process of the ion exchange resin with thick sludge, because waste acid and waste alkali are harmful substances. EKF Ruling classifies Sajó River into Category II, and provides that effluent standards should be satisfied. Therefore, it is desirable to discharge waste acid and waste alkali in proportion to the flow of Sajó River after neutralizing and diluting them in neutralizing reservoirs so as to satisfy the applicable standards.

3) Prevention of ash scattering from the sludge storage area

EKF Ruling 12 has laid down to plan the recultivation of existing block with the sludge piled up in order to prevent ash scattering from the sludge storage area after use. The following measures should be taken;

(a) For the sludge storage area after use, soil coverage or planting, and

(b) For the coal washing sludge area, after the coal washing plant is closed and the sale of coal washing sludge to brick plant is completed, soil coverage or planting.

4) Measures to meet increased demand for water supply

There are two sources for water supply, Borsodszirak I and Borsodszirak I/A downstream the groundwater of sludge storage area. Among these two sources, I/A is out of use at present due to decrease in demand and deterioration in the quality of water, or the water supply is covered by the source I, only. The source I introduces the water from Bodva River into the reservoirs and furnishes almost all of the water supply through a series of treatment consisting of ground infiltration, pumping and sand filtration (Groundwater is also pumped from wells, treated and furnished partially).

There are two possible methods of protecting the sources from the existing groundwater pollution; one is to intercept polluted groundwater veins, and the other is to remove the contaminants from polluted groundwater pumped. However, if the sources are intercepted upstream the source I by impermeable wall, secondary influences may occur due to the presence of the waste illegally dumped upstream the impermeable wall; the groundwater dammed up and spreading around elutes harmful substances contained in the waste, or the groundwater level rising near the surface layer elutes fertilizers and agricultural chemicals. Therefore, prior to the application of the former, it is necessary to implement detailed survey on the environmental impact. Other reasons of disabling from using impermeable wall is that machinery for excavation is not available in Hungary and the cost sharing is too heavy compared to that by other methods.

The latter, an effective method for local high concentration groundwater pollution, is not practically applicable to Borsod Power Plant, where low concentration groundwater pollution covers a wide range thereof.

As mentioned above, it is extremely difficult to take effective measures against groundwater pollution. It is essential to necessary measures to prevent groundwater pollution from occurring. It is possible at present to secure the water supply without using the source I/A due to the decrease in the demand. However, in the expectation that the industrial production will be gradually recovered hereafter in Hungary, it is conceivable to meet the increase in the demand for water supply in the future by enlarging the capacity of the source I, comprising a series of reservoirs, pumping and sand filtration.

5) Other solid waste

Besides the combustion residue, acid waste and alkali waste, major waste that may be discharged from Borsod Power Plant are as follows.

- Water treatment plant : Sludge, ion exchange resin after use
- Boilers : Drain and oily materials from water storage tank
- Substations : Waste transformer oil and polluted gravel packed bed
- Equipment maintenance : Waste oil, oily sludge, etc.

In Borsod Power Plant, partitions have been arranged in a concrete-floored building enclosed by wire netting so as to sort the waste, and the waste oil is stored in vessels. After this, the waste is taken over by MÉH Co., ÁFOR, MOR Rt, ÉSZAKKÖR Kft, Dorog Hulladékegétő Kft, Miskolc Municipal Refuse Disposal Company, etc. for recycling or disposition. It is considered that these facilities will be able to fully dispose of the waste even after the operation of new CFB unit is started.

6) Waste produced during construction

Non-hazardous waste that may arise during construction includes construction offal, piping scraps and metal waste in iron and copper. MÉH Co. and North Hungarian Waste Managing Ltd. are able to take over salable metal waste and construction offal for that can be used for recultivation in the landfill, respectively. The soil that may arise from the civil works including excavation can be also taken over by the landfill located at Mucsonyi Street, Kazincbarcika for recultivation of the dumping area, or by Borsodchem Co.

For hazardous waste, licensed companies will take over the transportation and handling including harmlessness treatment. These companies are listed in "Environmental Protection" that can be purchased from Building Industrial Information Center.

6.7 Environmental Monitoring Programs

6.7.1 Environmental Monitoring During Construction Operations

The purpose of environmental monitoring is to prevent or reduce the phenomena that may affect the health or living environment of inhabitants during construction. In addition, it is necessary to take into consideration the environment of construction operation for this purpose.

The following items are monitored conforming to the present regulations and criteria in order to minimize the environmental impact that may occur during construction. For each item, measurement, analysis and assessment are carried out regularly and timely.

- Proper treatment of wastes produced by construction works
- Preventing asbestos from scattering during the demolition of existing buildings
- Controlling noise and vibration arising from construction machines, heavy machinery and vehicles
- Preventing excavated soil from affecting rivers in the periphery of construction works during raining
- Preventing secondary pollution from occurring due to polluted soil moved after excavation

In Hungary strict regulations have come into effect concerning the collection, treatment and harm-neutralizing processing of hazardous waste, and these regulations must be observed. Government decree No. 102/1996 (VII,12) has been issued on hazardous substances in detail, and legal penal regulations have been stipulated against its infringement.

It is also necessary to prepare suitable storage places in the case hazardous waste is collected and stored temporarily in conformity with the environmental protection regulations laid down in Government decree No. 56/ 1981 (XI, 18, MT).

Discharge of industrial waste and sewage into rivers requires meeting the regulations laid down in Government decree No. 4/1984 (II, 7, OVH). For the purpose of observing these regulations and standards, the Study Team proposes to coordinate environmental control systems. Namely, the body established after coordination, taking a leading part, shall draw up environmental monitoring programs and perform monitoring to minimize possible impact on the environment.

Table 6.7.1 roughly shows the hazardous substances anticipated to arise during the period of executing planned construction work conforming to decree No. 102/1996 (VII, 12).

Table 6.7.1 Hazardous Waste and Designated Categories

Code	Name	Category
V+++++03	polluted cellulose, filter-paper, paper board	***
V+++++15	polluted soil become waste	***
V+++++19	soil, rock, gravel become waste	***
V31429	non-dusting lumpy waste of high asbestos content	III
V31430	waste containing asbestos dust and fibbers	I
V+++++02	polluted iron and steel, and their alloys	***
V+++++18	polluted color and light metals, and their alloys	***
V35501	batteries	I
V35503	electrical wastes	***
V53202	wood-preserving and wood-preserving residues of expired guarantee; wood-preserving and wood-preserving residues unusable by their qualification	***
V53204	combustion retarder residues of expired guarantee	***
V54102	refused oil	II
V54107	oil used for drilling, cutting and lapping	II
V54711	oily sludge from metal working	II
V55501	lacquer residues	II
V55502	dye and lacquer of expired guarantee	II
V55504	dye residues	II
V55505	residues of coating materials	II
V55903	polymerized, solidified resin residues	II
V55904	liquid resin residues	***

Note: In case of hazardous wastes signed by +++++, code of polluting component has to be given.

The outline of decree No. 102 in relation to Borsod Power Plant is roughly described as follows.

(1) If any item is listed as a hazardous substance but not designated in any category of Table 6.8.1 shown above, such item is considered to have the same components as those of the most hazardous substance, and subjected to the application of the regulations in conformity thereto.

(2) It must be emphasized that collecting places are arranged for hazardous substances that may arise during the period of construction. Such collecting places are classified into open type or closed type depending on the type of hazardous waste. Annex I of the above said regulations includes the conditions required for the collecting places.

(3) Hazardous substances that may arise during the period of construction must be registered conforming to these regulations. Transportation, pre-treatment, treatment, harm-neutralizing processing must be implemented by licensed corporations or private persons.

(4) Prevention of soil pollution by construction machinery must be taken into account during the period of construction. For this purpose, fuel vessels for such machinery must be provided. The body responsible for environmental protection will lay down soon the regulations applicable to the fabrication of the vessels to be used during the licensed period. Attention must be called to the contingency that, if the soil polluted with oil and fuels is regarded as a hazardous substance and any pollution arises, such soil must be collected.

6.7.2 Environmental Monitoring after Plant Commissioning

The Study Team proposes that Borsod Power Plant draw up a program for monitoring the following items that may apply to environmental loads after plant commissioning in order to secure earliest discovery of pollution or contamination and to take necessary countermeasures promptly. When a part of coal is transported by trucks, road transport will be also monitored.

(1) Flue Gas Monitoring (using newly installed stations)

Regular monitoring of SO_2, NOx, CO, dust, wind direction and wind velocity

It is necessary to regularly monitor the concentration of emission gas including SO_2 in order to decide the clearance of emission standards and discover the cause if applicable emission standards are exceeded. Flue gas monitoring is indispensable also for assessing the effect of the measures newly taken in.

(2) Ambient Air Monitoring (using existing stations)

Continuous monitoring of SO_2, NOx, CO, dust, wind direction and wind velocity

Near Borsod Power Plant, there are regular monitoring stations, J-2, J-3, EC-2, EC-3 and JM1. After fitting the machines and materials, the Study Team proposes that Borsod Power Plant monitor, using the data available from existing stations.

Although decrease in the emission from sources including SO_2 is directly reflected by the concentration in the environment, the ratio of contribution to optional measuring spots by stationary sources, mobile sources and area sources substantially changes depending on weather conditions, and the concentration in the environment itself may be remarkably changeable. Therefore, it is necessary to monitor regularly every air pollutant, analyze and assess the data combined with weather conditions.

(3) Establishment of Continuous Monitoring Networks for Emissions and Ambient Air by Combining (1) and (2) Above

At present, the sources and environment are under the control of vertically structured two administrative bodies, EKF and ANTSZ. The Study Team proposes to unify these two bodies to provide prompt responsiveness.

Even if a serious situation substantially exceeding the air quality standards occurred, it is possible to take necessary measures promptly and properly relying on a regular monitoring network, and it is also possible to issue an urgent demand for decreasing emission to every source facility.

(4) Groundwater Monitoring

The items affecting the environment will be analyzed and assessed using regularly sampled water.

Main pollutants discharged from Borsod Power Plant that affect the groundwater are As and ions. As the target areas of the survey involve many sources, other related items and heavy metals should be also included in the range of selected items. Since March 1996, Borsod Power Plant has adopted a thick sludge transport system, and simultaneously started observing present water level and measuring the quality of water every month and every quarter of the year, respectively, in several monitoring wells. It is necessary to continue these operations also hereafter. A remarkably long period of time is necessary until the effect of the measures taken for preventing groundwater pollution appears clearly. Therefore, assessment is necessary by identifying the changes in the concentration on each measuring spot with the passage of time. In some cases, it will be also necessary to increase the number of monitoring wells and exchange monitoring data mutually with other bodies for more practical use.

(5) Regular Monitoring of Other Items Including Effluents, Noise and Traffic Volume

Chapter 7

Project Implementation Plan

Chapter 7 Project Implementation Plan

7.1 Basic Considerations for Contracting Method

In order to establish construction schedule, owner's project management organization and contracting methods must be considered. If owners do not have enough man-power, technical and financial expertise, they can hire consultants for the supports.

Contracting methods can be categorized into the following two schemes.

(1) Full turn key contract

The owner contracts to one contractor which assumes a sole responsibility for the construction of the plant.

(2) Separate contracts

The project is devided into several packages that are tendered and contracted separately.

In the case of the separate contracts, packaging is made according to the contractors' or manufacturers' specialties. Therefore, it is possible to obtain the best quality performance with relatively low price. However, contractors only warrant the performance of specific field, not that of the whole plant.

In the case of the full turn key contract, the owner can let a contractor to warrant the specified performance of the whole plant. As only one tender document is required for the contract, the project period can be shorter. In general, in order to make a contractor to guarantee the performance of the whole plant, the contract price tend to be higher than that of the separate contracts.

As there is a time limit for the project period, the new 150 MW plant and the renovation of existing facilities are assumed to be contracted separately as a turn-key basis. It is also assumed that owner will have a technical and administration assistance from consulting firms.

As civil and architectural works precede the other works and are to be contracted to Hungarian companies, these works are separated from the above turn-key contracts.

The project is divided into the following four(4) parts which will be contracted separately.

1) Civil/architectural works for the new 150 MW unit

2) Equipment provision and installation works for the new 150 MW unit (turn-key basis including test-runs)

3) Civil/architectural works for the renovation of the existing facilities

4) Equipment provision and installation works for the renovation of the existing facilities. (turn-key basis including test-runs)

7.2 Construction Schedule

7.2.1 Special Considerations for Construction Schedule

The following principles have been employed for developing construction schedules for the new 150 MW unit and the renovation of the existing facilities.

(1) The construction period for the new 150 MW unit is approximately 5 years. As the construction permission for the new plant has to be acquired in 1997, application for the permission must be made as soon as possible.

(2) The construction period of the renovation of the existing facilities is approximately 3 years. The renovation should be completed well before the enforcement of the new emission standards in early 2005.

(3) The negative effect of the construction works on the power plant total output should be minimized.

(4) The project investment is preferably distributed evenly over the project period.

The overall construction schedule for the project must be devised giving due considerations for above items. The renovation of the existing facilities should be started after the completion of the construction of the new 150 MW plant.

The followings are special considerations for construction schedule.

(1) Power plant construction approval (the new 150 MW unit)
(2) Funding arrangement
(3) Basic/detailed design and preparation of tender documents
(4) Period between tender opening and contract

(5) Civil engineering design based on actual equipment weights

(6) Drawings submitted by contractors and their approval by the owner

(7) Construction supervision and safety management

(8) Individual equipment test-runs and system and/or equipment adjustments

7.2.2 Construction Schedule for the New 150 MW Plant

Construction schedule for the new 150 MW unit is shown in Table 7.2.1.

(1) Preparation phase (items 1,2,3,4 of the " Time Schedule")

1) The preparation phase includes the preparation of the detailed environmental impact study. After the detailed environmental impact study, the licensing process will follow.

2) The planning/design process was designed to have two phases so that the result of the tender evaluation will be taken into the design. The final execution plans may be prepared after the successful tenderer (the manufacturer) has supplied the necessary data.

(2) Erection Phase

1) The preparatory activity includes the preparation of the two independent sites.

a) Demolishing the existing structures at site where the temporally facilities will be erected. Installation of water pipes, electricity lines, depots, offices, locker-rooms, showers, lifting equipment for the on-site preliminary erection work.

b) Demolishing existing structures, relocating sewage pipes at the area where the new 150 MW unit will be located.

2) The underground civil structures (ducts, water supply and sewer lines) and foundation works for the new equipment.

3) The main equipment (boiler, turbine, cooling towers, etc.) manufactured at the factories is transported to the power station. The equipment is moved to its final location in the plant.

4) After erecting the main equipment, installation of supplementary equipment (feed pumps, heat exchangers, pipelines, fittings, etc.) will follow.

5) As the mechanical erection works progress, the electrical works regarding cabling, electric power transmission, instrumentation and control will start.

6) The erection phase includes items 5～19 of the " Time schedule" .

(3) Operational Tests, Test Run, Commercial Operation

1) After having erected all equipment and elements, service tests of each equipment may follow (item 20):

(a) Cold service tests
(b) Hot service tests

2) After successful hot service tests, the test run of the new unit may begin (item 21).

3) Through the test run, the contractor proves that the equipment supplied is capable of satisfying the specified parameters in the tender documents, then submits the test records.

4) The process of handing over/taking over, and the commercial operation will follow (item 22).

7.2.3 Construction Schedule for Renovation of the Existing Facilities

Construction schedule for the new 150 MW plant is shown in Table 7.2.2.

The optional contract with the contractor of the existing facilities can be considered.

The design period will last seven month even after the contract of equipment provision and installation since detailed specifications of equipment from successful contractor is required for design of equipment concrete bases, piping and instrumentation.

Replacement works of four boilers will be done one by one to minimize the negative effect on the power plant total output. As a result, test operations and acceptance tests will be done separately. The construction of new fuel (gas and oil) supply systems will be completed before the completion of the replacement works of the first boiler.

Table 7.2.1 Time Schedule for Construction of the New 150 MW Plant

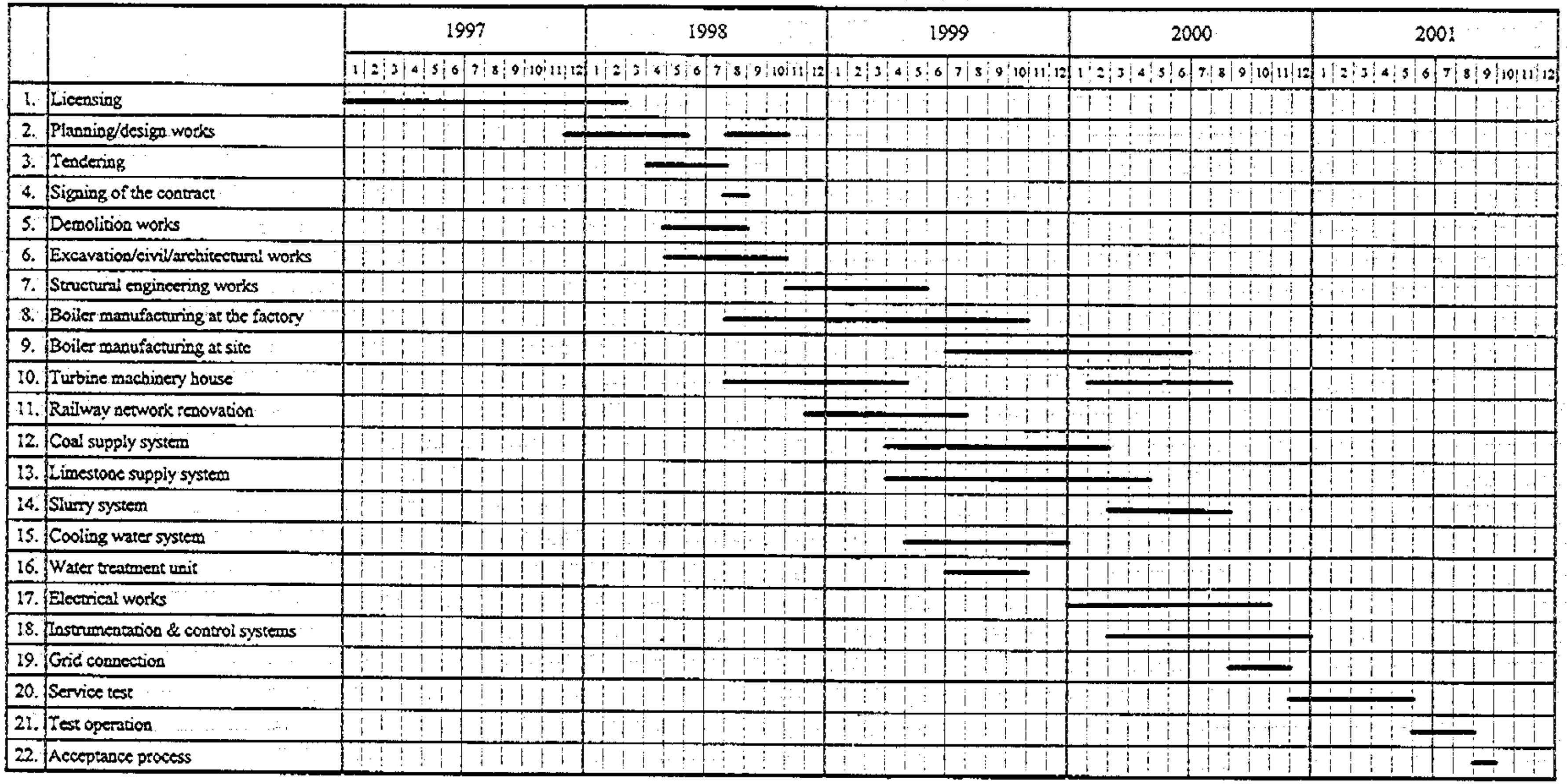
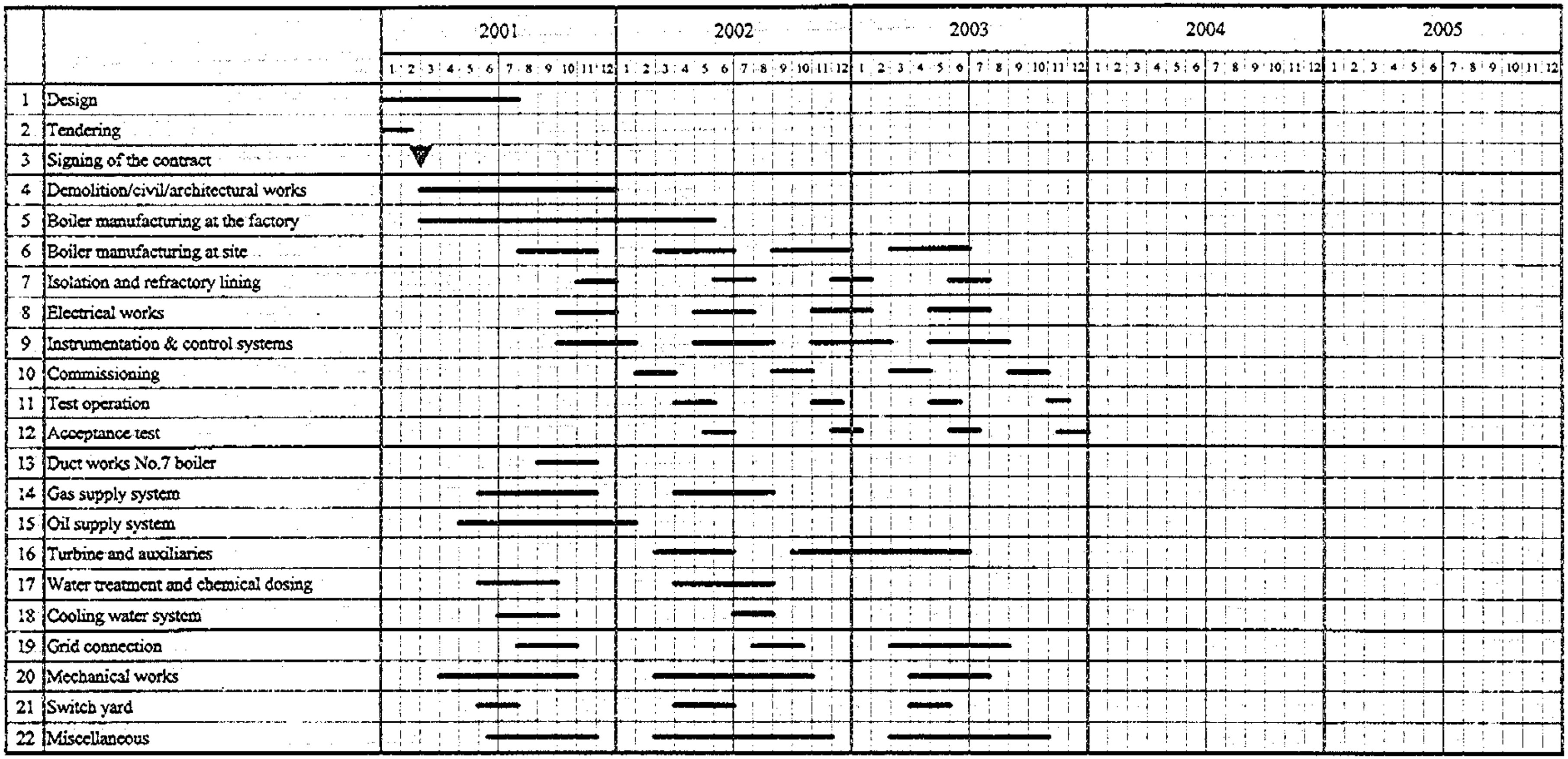


Table 7.2.2 Time Schedule for Renovation of Existing Facilities



Chapter 8

Project Cost

Chapter 8 Project Cost

8.1 Basic Approach for Project Cost Estimation

8.1.1 Assumptions

As studied in section 7, full turn key contracts for both the new 150 MW plant and the renewal of the existing plant are assumed. Consulting fees for technical and administrative support are to be included in the estimate.

There are two funding options for the project, which are by own resources and by loans. As the power plant operation has been privatized, it is difficult to obtain loans from World Bank, OECF etc. which normally have lower interest rates but also several restrictions for funding. Therefore, for this study, it is assumed that the project will be funded by the loans with a little restrictions such as untied loan from Japan Export Import Bank.

In order to enhance the development of domestic industry in Hungary, local equipment and materials shall be utilized at the full extent. In this study, it is assumed that equipment and materials shall be procured locally as much as possible although the final decision for the procurement will be made solely by the owner.

As the owner is private firm, custom duties are include in the estimation.

Water and electricity for construction are provided free of charge to the contractors.

8.1.2 Cost Estimation Criteria

The following criteria were used to prepare project cost estimates.

1) Market prices in 1993 surveyed in the EGI F/S study were used as the base prices.

2) The prices of equipment to be imported were adjusted by assuming a 3%/year inflation rate on the US dollar basis up to 1997.

3) The changes in the HUF/US$ exchange rate between 1993 and 1997 were taken into consideration. The exchange rate applied for 1997 is 161.06 HUF/US$.

4) For items such as the limestone plant that were not included in the EGI F/S study, market prices in 1997 were surveyed.

5) For costs of the civil works, a price increase factor of 2.078 between 1993 and 1997 was used.

6) For costs of mechanical installation works, a price increase factor of 1.8635 between 1993 and 1997 was used.

7) The cost estimate table was prepared in compliance with the authorized format used in the Hungarian power industry.

8 % of direct costs for the new 150 MW plant and 10 % of direct costs for the renovation of the existing facilities were reserved for contingencies (technical reserve). The latter has a larger percentage since renovation works are more likely to be affected by the existing facility conditions which are not fully investigated by now.

The consulting fees will vary widely depending on the scope of works and the duration which will be decided by the owner. Therefore, these were calculated as 6.5% of the direct construction cost conforming the standard estimation methods in Hungry.

8.2 Project Cost

Construction cost and yearly investment schedule for the proposed project (CFBC type) for the new 150 MW plant are shown in Tables 8.2.1 and 8.2.2, respectively. Those for the alternative project (pulverized coal combustion + wet-type flue gas desulfurization) are shown in Tables 8.2.3 and 8.2.4. Since the construction cost for the alternative project is 10 % higher than the proposed project, the proposed project is financially more feasible. While the proposed project employs the relatively new technology, CFBC, of which number of the equipment suppliers is limited, the alternative project utilizes pulverized coal combustion technology which is common worldwide and flue gas desulfurization which is also quite popular in developed countries. The construction cost for the alternative project is expected to become lower due to the serious competition in this market. Therefore, the 15 % cost reduction for the alternative project is assumed at economic and financial analysis which are set out in the next chapter.

Construction cost and yearly investment schedule for the proposed project of the renovation of the existing facilities are shown in Tables 8.2.5 and 8.2.6, respectively. Those for the alternative project (pulverized coal combustion + semi-dry flue gas desulfurization) of the renovation of the existing facilities are shown in Tables 8.2.7 and 8.2.8. As the construction cost of the alternative project is more than 30 % higher than that of the proposed project, the proposed project is financially more feasible.

Table 8.2.1 Construction Cost for the New 150 MW Unit (Proposed Project)

Price level. 1997
Currency: MHUF

	Designation	Civil work	Local	Import	Custom duty	Erection	Other	Total capital	Other develop-ment cost	Total invest-ment
01	Design						1140.00	1140.00		1140.00
02	Site preparation	91.00	31.00					122.00		122.00
03	Leveling	9.60						9.60		9.60
04	Roads	29.50						29.50		29.50
05	Railway siding	58.60	17.80	10.00	0.90	31.00		118.30		118.30
06	Fence	14.50						14.50		14.50
08	Demolition	31.20	19.50					50.70		50.70
91	Main-building	535.00						535.00		535.00
92	Chimney (reconstruction)	290.00						290.00		290.00
93	Boiler and furnace installation	93.50		5591.00	671.00	1081.00	151.80	7588.30		7588.30
94	Steam turbine	145.80	1752.00					1897.80		1897.80
95	Alternator and Block-transformer	139.20	364.30			8.40		511.90		511.90
96	Feed system		168.50	964.50	84.30	326.50	48.00	1591.80		1591.80
97	Cranes (Main-building) reconstruction		95.00					95.00		95.00
98	Electrical equipment (Main-building)		524.60	509.60		177.80		1212.00		1212.00
99	Control system		233.60	735.70	79.40	270.10	19.40	1338.20		1338.20
100	Fuel transport, storing	372.00	532.00	79.70	6.70	184.00		1174.40		1174.40
101	Limestone handling	235.00	212.00	30.80	2.20	72.80		552.80		552.80
11	Slag and ash removal	10.00	170.00			76.80		256.80		256.80
12	Cooling water system	155.40	342.60	102.30	11.20	113.00		724.50		724.50
13	Water treatment system	59.50	320.50	50.30	5.60	87.50		523.40		523.40
14	Outdoor switch gear	23.80	33.70			6.40		63.90		63.90
15	Workshop (reconstruction)	24.50	39.10					63.60		63.60
16	Offices	11.00						11.00		11.00
18	Life and property defense	5.00	19.80	4.80	0.50	7.90		38.00		38.00
19	Environmental protection	35.30	47.60					82.90		82.90
20	Area light	19.00						19.00		19.00
21	Fire fighting systems	26.00	45.70	8.00	0.70	14.00		94.40		94.40
22	Technology and installation piping	71.50	11.20					82.70		82.70
23	Canalization	81.40						81.40		81.40
25	Laboratory		13.00					13.00		13.00
26	Costs of Investor's services and trial run						500.00	500.00		500.00
27	Costs of P.P. Company during commissioning							0.00		0.00
28	Administrative costs of Investment and bank charges							0.00		0.00
29	Traffic and transport equipment		21.00					21.00		21.00
30	Telecommunication and fire alarm system	47.70	176.00	36.20	4.20	55.00		319.10		319.10
32	Means of organization on site	64.40	176.80					241.20		241.20
33	Miscellaneous cost	80.00				22.80		102.80		102.80
34	Expenses of not installed equipment		160.00	197.00	18.00			375.00		375.00
35	Expenses for acceleration of the Investment							0.00		0.00
36	Technical reserve (contingency)						1700.00	1700.00		1700.00
	01-36 Subtotal:	2759.40	5527.30	8319.90	884.70	2535.00	3559.20	23585.50		23585.50
	Connected Costs: Electrical connection: Gas connection.									
	Total cost Investment. Engineering fee (6,5 %)	100.00	450.00	350.00	10.00	523.00	100.00	1533.00		1533.00
	Total	2859.40	5977.30	8669.90	894.70	3058.00	3659.20	25118.50	0.00	25118.50

Table 8.2.2 Investment Schedule for Construction of the New 150MW Plant
(Proposed Project)

Price level: 1997
Currency: MHUF

Year	Civil work	Local	Import	Custom duty	Erection	Others	Total capital cost	Other development cost	Base investment total
1997						60.00	60.00		60.00
1998	1687.00	910.00	990.00	94.00	107.00	980.00	4768.00		4768.00
1999	974.00	2411.00	4976.00	506.00	1508.00	200.00	10575.00		10575.00
2000	198.40	2656.30	2703.90	294.70	1433.00	179.00	7465.30		7465.30
2001					10.00	2240.20	2250.20		2250.20
Total	2859.40	5977.30	8669.90	894.70	3058.00	3659.20	25118.50	0.00	25118.50

Table 8.2.3 Construction Cost for the New 150MW Plant (Alternative Project)

Price level: 1997
Currency: MHUF

	Designation	Civil work	Local	Import	Custom duty	Erection	Other	Total capital	Other develop-ment cost	Total invest-ment
01	Design						1450.00	1450.00		1450.00
02	Site preparation	104.00	35.50					139.50		139.50
03	Leveling	10.90						10.90		10.90
04	Roads	30.40						30.40		30.40
05	Railway siding	58.60	17.80	10.00	0.90	31.00		118.30		118.30
06	Fence	14.50						14.50		14.50
08	Demolition	33.10	19.50					52.60		52.60
91	Main-building	535.00						535.00		535.00
92	Chimney (reconstruction)	290.00						290.00		290.00
93	Boiler and furnace installation	87.10		4480.00	537.60	691.50	75.80	5872.00		5872.00
94	Steam turbine	145.80	1752.00					1897.80		1897.80
95	Alternator and Block-transformer	139.20	364.30			8.40		511.90		511.90
96	Feed system		168.50	964.50	84.30	326.50	48.00	1591.80		1591.80
97	Cranes (Main-building) reconstruction		95.00					95.00		95.00
98	Electrical equipment (Main-building)		524.60	509.60		177.80		1212.00		1212.00
99	Control system		233.60	735.70	79.40	270.10	19.40	1338.20		1338.20
100	Fuel transport, storing	372.00	532.00	79.70	6.70	184.00		1174.40		1174.40
101	Limestone handling	275.00	305.00	34.60	2.40	97.00		714.00		714.00
11	Slag and ash removal	10.00	170.00			76.80		256.80		256.80
12	Cooling water system	155.40	342.60	102.30	11.20	113.00		724.50		724.50
13	Water treatment system	59.50	320.50	50.30	5.60	87.50		523.40		523.40
14	Outdoor switch gear	23.80	33.70			6.40		63.90		63.90
15	Workshop (reconstruction)	24.50	39.10					63.60		63.60
16	Offices	11.00						11.00		11.00
18	Life and property defense	5.00	19.80	4.80	0.50	7.90		38.00		38.00
19	Environmental protection + FGD	97.10	47.60	2450.10	205.80	483.00		3283.60		3283.60
20	Area light	19.00						19.00		19.00
21	Fire fighting systems	26.00	45.70	8.00	0.70	14.00		94.40		94.40
22	Technology and installation piping	71.50	11.20					82.70		82.70
23	Canalization	81.40						81.40		81.40
25	Laboratory		13.00					13.00		13.00
26	Costs of Investor's services and trial run						550.00	550.00		550.00
27	Costs of P.P. Company during commissioning							0.00		0.00
28	Administrative costs of Investment and bank charges							0.00		0.00
29	Traffic and transport equipment		21.00					21.00		21.00
30	Telecommunication and fire alarm system	47.70	176.00	36.20	4.20	55.00		319.10		319.10
32	Means of organization on site	69.30	191.40			24.60		285.30		285.30
33	Miscellaneous cost	80.00						80.00		80.00
34	Expenses of not installed equipment		160.00	211.00	19.90			390.90		390.90
35	Expenses for acceleration of the Investment							0.00		0.00
36	Technical reserve						1950.00	1950.00		1950.00
	01-36 Subtotal:	2876.80	5639.40	9676.80	959.20	2654.50	4093.20	25899.90		25899.90
	Connected Costs: Electrical connection:									
	Gas connection:									
	Total cost Investment:									
	Engineering fee (6,5 %)	120.00	410.00	370.00	10.00	725.00	50.00	1685.00		1685.00
	Altogether	2996.80	6049.40	10046.80	969.20	3379.50	4143.20	27584.90	0.00	27584.90

Table 8.2.4 Investment Schedule for Construction of the New 150MW Plant
(Alternative Project)

Price level: 1997
Currency: MHUF

Year	Civil work	Local	Import	Custom duty	Erection	Others	Total capital cost	Other development cost	Base investment total
1997						70.00	70.00		70.00
1998	1728.00	947.00	1078.00	106.00	119.00	1160.00	5138.00		5138.00
1999	1064.00	2414.00	5818.00	562.00	1584.00	240.00	11682.00		11682.00
2000	204.80	2688.40	3150.80	301.20	1666.50	203.20	8214.90		8214.90
2001					10.00	2470.00	2480.00		2480.00
Total	2996.80	6049.40	10046.80	969.20	3379.50	4143.20	27584.90	0.00	27584.90

Table 8.2.5 Construction Cost for Renovation of the Existing Facilities (Proposed Project)

Price level: 1997
Currency : MHUF

	Designation	Civil work	Local	Import	Custom duty	Erection	Other	Total capital	Other development cost	Total investment
01	Design						310.00	310.00		310.00
02	Site preparation	15.00	5.00					20.00		20.00
03	Leveling	6.00						6.00		6.00
04	Roads	6.00						6.00		6.00
05	Railway siding							0.00		0.00
06	Fence							0.00		0.00
07	Stores(reconstruction)	2.00	2.00				10.00	14.00		14.00
08	Demolition	30.00	20.00					50.00		50.00
91	Main-building	1124.00						1124.00		1124.00
92	Chimney (reconstruction)	12.00						12.00		12.00
93	Boiler and furnace installation	20.00	516.50	180.00	21.60	137.00	40.00	915.10		915.10
94	Steam turbine	92.00	910.00	100.00	12.00	196.00		1310.00		1310.00
95	Alternator and Block-transformer							0.00		0.00
96	Feed system		15.50	50.00	4.50	10.00		80.00		80.00
97	Cranes (Main-building) reconstruction							0.00		0.00
98	Electrical equipment (Main-building)		195.00	200.00	18.00	67.00		480.00		480.00
99	Control system		42.00	300.00	18.00	90.00		450.00		450.00
100	Fuel transport, storing	120.00	253.00	60.00	5.00	82.00		520.00		520.00
101	Limestone handling							0.00		0.00
11	Slag and ash removal							0.00		0.00
12	Cooling water system	30.00	60.00	10.00	1.00	9.00		110.00		110.00
13	Water treatment system	40.00	224.50	50.00	5.50	70.00		390.00		390.00
14	Outdoor switch gear	40.00	60.00	10.00	1.00	24.00		135.00		135.00
15	Workshop (reconstruction)	5.00	15.00					20.00		20.00
16	Offices	10.00						10.00		10.00
18	Life and property defense	2.00	2.00	3.00	0.30	0.70		8.00		8.00
19	Environmental protection	6.00	10.00	20.00	3.00	1.00		40.00		40.00
20	Area light	5.00						5.00		5.00
21	Fire fighting systems		3.00	8.00	1.00	3.00		15.00		15.00
22	Technology and installation piping		40.00	100.00	12.00	8.00		160.00		160.00
23	Canalization							0.00		0.00
25	Laboratory		15.00					15.00		15.00
26	Costs of Investor's services and trial run						40.00	40.00		40.00
27	Costs of P.P. Company during commissioning							0.00		0.00
28	Administrative costs of Investment and bank charges							0.00		0.00
29	Traffic and transport equipment		10.00					10.00		10.00
30	Telecommunication and fire alarm system	10.00	30.00					40.00		40.00
32	Means of organization on site	10.00	35.00			15.00		60.00		60.00
33	Miscellaneous cost							0.00		0.00
34	Expenses of not installed equipment		7.00	30.00	3.00			40.00		40.00
35	Expenses for acceleration of the Investment							0.00		0.00
36	Technical reserve (contingency)						686.00	686.00		686.00
	01-36 Subtotal:	1585.00	2470.50	1121.00	105.90	712.70	1086.00	7081.10		7081.10
	Connected Costs: Electrical connection:									
	Gas connection									
	Total cost Investment									
	Engineering fee (6,5%)							460.27		460.27
	Total							7541.37	0.00	7541.37

Table 8.2.6 Investment Schedule for Renovation of the Existing Facilities
(Proposed Project)

Price level: 1997
Currency : MHUF

Year	Civil work	Import	Custom duty	Erection	Others	Total capital cost	Other development cost	Base investment total
2001	570.00	60.00	5.60	145.80	410.00	1931.40		1931.40
2002	785.00	595.00	56.20	129.80	350.00	2536.00		2536.00
2003	185.00	456.00	43.10	407.10	777.20	2978.90		2978.90
2004	45.00			15.00	5.10	65.10		65.10
2005		10.00	1.00	15.00	4.00	30.00		30.00
Total	1585.00	1121.00	105.90	712.70	1546.30	7541.40	0.00	7541.40

Table 8.2.7 Construction Cost for Renovation of the Existing Facilities
(Alternative Project)

Price level 1997
Currency : MHUF

	Designation	Civil work	Local	Import	Custom duty	Erection	Other	Total capital	Other develop-ment cost	Total invest-ment
01	Design						430.00	430.00		430.00
02	Site preparation	15.00	5.00					20.00		20.00
03	Leveling	6.00						6.00		6.00
04	Roads	6.00						6.00		6.00
05	Railway siding							0.00		0.00
06	Fence							0.00		0.00
07	Stores(reconstruction)	2.00	2.00				10.00	14.00		14.00
08	Demolition	30.00	20.00					50.00		50.00
91	Main-building	1124.00						1124.00		1124.00
92	Chimney (reconstruction)	12.00						12.00		12.00
93	Boiler and furnace installation	22.00	280.00	120.00	14.00	128.00		564.00		564.00
94	Steam turbine	92.00	910.00	100.00	12.00	196.00		1310.00		1310.00
95	Alternator and Block-transformer							0.00		0.00
96	Feed system		15.50	50.00	4.50	10.00		80.00		80.00
97	Cranes (Main-building) reconstruction							0.00		0.00
98	Electrical equipment (Main-building)		195.00	200.00	18.00	67.00		480.00		480.00
99	Control system		42.00	300.00	18.00	90.00		450.00		450.00
100	Fuel transport, storing	85.00	180.00	43.00	4.00	58.00		370.00		370.00
101	Limestone handling							0.00		0.00
11	Slag and ash removal							0.00		0.00
12	Cooling water system	30.00	60.00	10.00	1.00	9.00		110.00		110.00
13	Water treatment system	40.00	224.50	50.00	5.50	70.00		390.00		390.00
14	Outdoor switch gear	40.00	60.00	10.00	1.00	24.00		135.00		135.00
15	Workshop (reconstruction)	5.00	15.00					20.00		20.00
16	Offices	10.00						10.00		10.00
18	Life and property defense	2.00	2.00	3.00	0.30	0.70		8.00		8.00
19	Environmental protection	60.00	140.00	2000.00	170.00	221.50		2591.50		2591.50
20	Area light	5.00						5.00		5.00
21	Fire fighting systems		3.00	8.00	1.00	3.00		15.00		15.00
22	Technology and installation piping		40.00	100.00	12.00	8.00		160.00		160.00
23	Canalization							0.00		0.00
25	Laboratory		15.00					15.00		15.00
26	Costs of Investor's services and trial run						40.00	40.00		40.00
27	Costs of P.P. Company during commissioning							0.00		0.00
28	Administrative costs of Investment and bank charges							0.00		0.00
29	Traffic and transport equipment		10.00					10.00		10.00
30	Telecommunication and fire alarm system	10.00	30.00					40.00		40.00
32	Means of organization on site	10.00	35.00			15.00		60.00		60.00
33	Miscellaneous cost							0.00		0.00
34	Expenses of not installed equipment		7.00	30.00	3.00			40.00		40.00
35	Expenses for acceleration of the Investment							0.00		0.00
36	Technical reserve (contingency)						918.00	918.00		918.00
	01-36 Subtotal:	1606.00	2291.00	3024.00	264.30	900.20	1398.00	9433.50		9433.50
	Connected Costs. Electrical connection.									
	Gas connection.									
	Total cost Investment									
	Engineering fee (6,5 %)							616.43		616.43
	Total							10099.93	0.00	10099.93

Table 8.2.8 Investment Schedule for Renovation of the Existing Facilities (Alternative Project)

Price level: 1997
Currency : MHUF

Year	Without Custom duty	Custom duty	Base investment total
2001	2249.35	88.10	2337.45
2002	2799.05	88.10	2887.15
2003	3782.70	88.10	3870.80
2004	59.20		59.20
2005	945.30		945.30
Total	9835.60	264.30	10099.90

Chapter 9

Economic and Financial Analyses