10.2.2 Economical Evaluation

Benefit and Cost calculated in accordance with above conditions is shown in Table 10.2-1.

Net Present Value (B-C), Benefit-Cost Ratio (B/C), Equivalent Discount Rate (Economic Internal Rate of Return) are as follows.

B-C	23,322.426 x 10^6 kčs
B/C	4.929
EIRR	39.54%

Thus it can be concluded that this project is superior to the reconstruction of the power station unless otherwise the discount rate does not exceed 39.54%.

10.2.3 Sensitivity Analysis

Sensitivity analysis is made based on the following conditions.

Case-1	20% Increase of the construction cost
Case-2	20% Increase of operation and maintenance cost

Flow of in above each case is shown in Table 10.2-2, 10.2-3. EIRR, B-C and B/C in each case are as follows. This table shows that this project is much superior to each case.

	Case-1	Case-2
B-C (x10^6kčs)	22,407.844	23,049.944
B/C	4.271	4.713
EIRR (%)	35.15	39.31

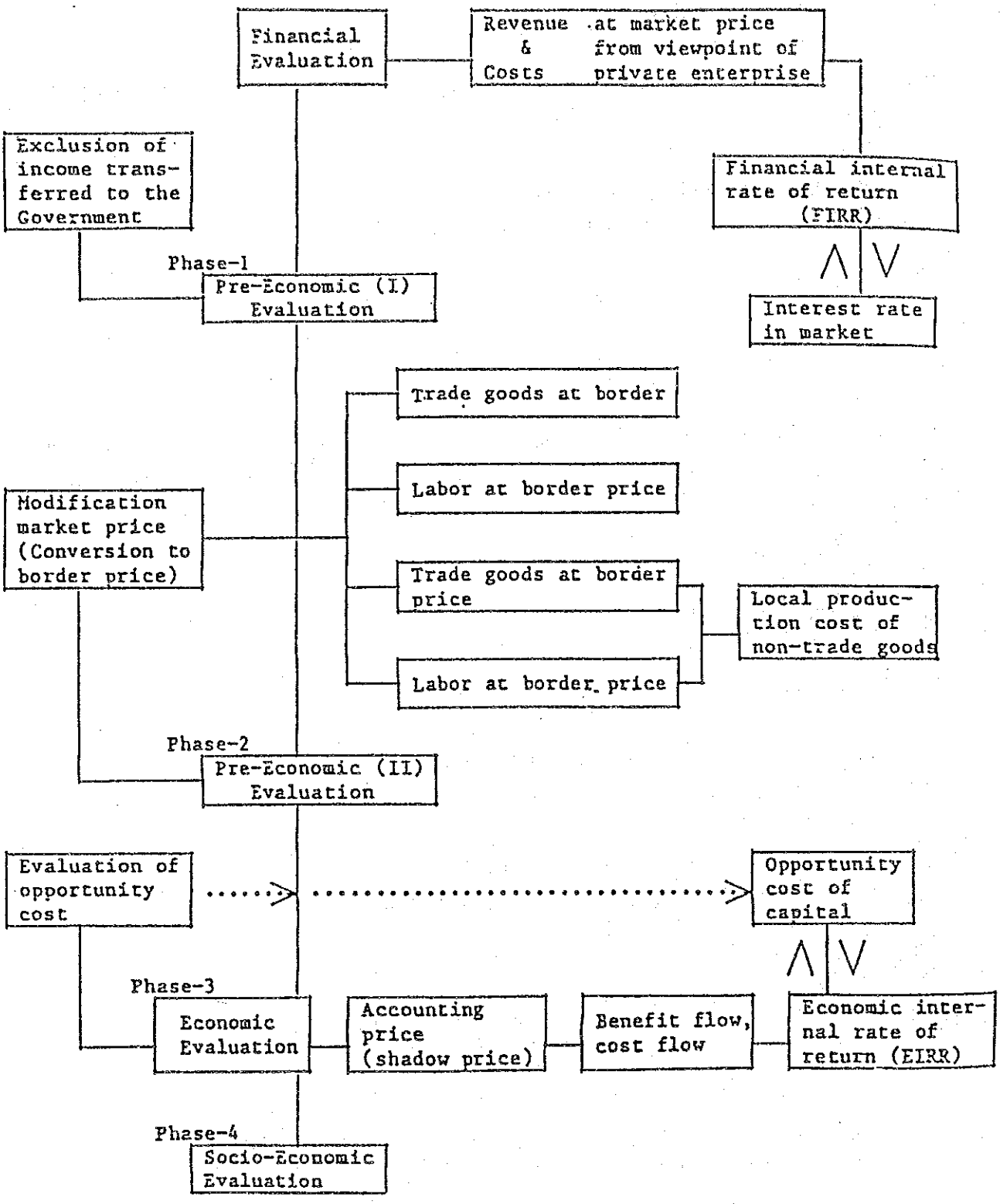


Figure 10.2-1 Flow Chart of Economic Evaluation

Table 10.2-1 Economic Evaluation

(Million Kcs)

	Costs					Benefits					
No. Year	Investmanet	Coal Cost	O&M Cost	Total Cost	Total Cost (N.P.V.)	Investment	O&M Cost	Fuel Cost	Total Benefit	Total Benefit (N.P.V.)	Benefits-Costs
1	150.531			150.531	136.846	15.317			15.317	13.924	-135.215
2	2436.346			2436.346	2013.509	247.893			247.893	204.874	-2188.443
3	1966.689			1966.689	1477.602	200.110			200.110	150.346	-1766.573
4	675.132			675.132	461.124	68.695			68.695	46.919	-606.427
5	645.778	0.000	65.992	711.770	441.953	65.708	-7.068	1361.060	1419.700	881.522	707.930
6	146.768	0.000	65.992	212.760	120.097	14.934	-7.068	1361.060	1368.926	772.723	1156.166
7		0.000	252.042	252.042	129.337		-30.532	5365.600	5335.068	2737.733	5083.026
8		0.000	252.042	252.042	117.579		-30.532	5365.600	5335.068	2488.349	5083.026
9		0.000	252.042	252.042	106.890		-30.532	5365.600	5335.068	2262.590	5083.026
10		0.000	252.042	252.042	97.173		-30.532	5365.600	5335.068	2056.900	5083.026
11		0.000	252.042	252.042	88.339		-30.532	5365.600	5335.068	1869.909	5083.026
12		0.000	252.042	252.042	80.308		-30.532	5365.600	5335.068	1699.917	5083.026
13		0.000	252.042	252.042	73.008		-30.532	5365.600	5335.068	1545.379	5083.026
14		0.000	252.042	252.042	66.371		-30.532	5365.600	5335.068	1404.890	5083.026
15		0.000	252.042	252.042	60.337		-30.532	5365.600	5335.068	1277.173	5083.026
16		0.000	252.042	252.042	54.852		-30.532	5365.600	5335.068	1161.066	5083.026
17		0.000	252.042	252.042	49.865		-30.532	5365.600	5335.068	1055.515	5083.026
18		0.000	252.042	252.042	45.332		-30.532	5365.600	5335.068	959.559	5083.026
19		0.000	252.042	252.042	41.211		-30.532	5365.600	5335.068	872.326	5083.026
20		0.000	252.042	252.042	37.464		-30.532	5365.600	5335.068	793.024	5083.026
21		0.000	252.042	252.042	34.059		-30.532	5365.600	5335.068	720.931	5083.026
22		0.000	252.042	252.042	30.962		-30.532	5365.600	5335.068	655.392	5083.026
23		0.000	252.042	252.042	28.148		-30.532	5365.600	5335.068	595.811	5083.026
24		0.000	252.042	252.042	25.589		-30.532	5365.600	5335.068	541.646	5083.026
25		0.000	252.042	252.042	23.262		-30.532	5365.600	5335.068	492.405	5083.026
26		0.000	252.042	252.042	21.148		-30.532	5365.600	5335.068	447.641	5083.026
27		0.000	252.042	252.042	19.225		-30.532	5365.600	5335.068	406.947	5083.026
28		0.000	252.042	252.042	17.477		-30.532	5365.600	5335.068	369.951	5083.026
29		0.000	252.042	252.042	15.888		-30.532	5365.600	5335.068	336.320	5083.026
30		0.000	186.050	186.050	10.662		-23.464	4004.540	3981.076	223.150	3795.026
31		0.000	186.050	186.050	9.693		-23.464	4004.540	3981.076	207.409	3795.026
Total	6021.243	0.000	6301.050	12322.292	5935.313	612.660	-763.301	134140.200	133989.559	29257.739	121667.065

Discount Rate 10.00%

Benefit 612.66

EDR 39.542

B-C(Discount Rate=10%) 23302.426

B/C(Discount Rate=10%) 4.927

Table 10.2-2 Economic Evaluation

(Million Won)

	Costs					Benefits						
No. Year	Investmnet	Coal Cost	O&M Cost	Total Cost	Total Cost (N.P.V.)	Investment	O&M Cost	Fuel Cost	Total Benefit	Total Benefit (N.P.V.)	Benefits-Costs
1	180.637			180.637	164.216	15.317			15.317	13.921	-150.221
2	2923.615			2923.615	2416.210	247.838			247.838	204.874	-2675.717
3	2360.026			2360.026	1773.123	200.110			200.110	150.346	-2159.936
4	810.158			810.158	553.349	68.695			68.695	46.919	-741.464
5	774.934	0.000	65.992	840.926	522.149	65.708	-7.068	1361.060	1419.700	881.522	573.774
6	176.121	0.000	65.992	242.113	136.667	14.934	-7.068	1361.060	1368.926	772.703	1106.812
7		0.000	252.042	252.042	129.337		-30.532	5365.600	5335.068	2737.738	5802.026
8		0.000	252.042	252.042	117.579		-30.532	5365.600	5335.068	2488.049	5083.026
9		0.000	252.042	252.042	106.890		-30.532	5365.600	5335.068	2262.590	5083.026
10		0.000	252.042	252.042	97.173		-30.532	5365.600	5335.068	2056.900	5083.026
11		0.000	252.042	252.042	88.339		-30.532	5365.600	5335.068	1868.909	5083.026
12		0.000	252.042	252.042	80.308		-30.532	5365.600	5335.068	1699.917	5083.026
13		0.000	252.042	252.042	73.008		-30.532	5365.600	5335.068	1545.379	5083.026
14		0.000	252.042	252.042	66.371		-30.532	5365.600	5335.068	1404.890	5083.026
15		0.000	252.042	252.042	60.337		-30.532	5365.600	5335.068	1277.173	5083.026
16		0.000	252.042	252.042	54.852		-30.532	5365.600	5335.068	1161.066	5083.026
17		0.000	252.042	252.042	49.865		-30.532	5365.600	5335.068	1055.515	5083.026
18		0.000	252.042	252.042	45.332		-30.532	5365.600	5335.068	959.559	5083.026
19		0.000	252.042	252.042	41.211		-30.532	5365.600	5335.068	872.326	5083.026
20		0.000	252.042	252.042	37.464		-30.532	5365.600	5335.068	793.024	5083.026
21		0.000	252.042	252.042	34.059		-30.532	5365.600	5335.068	720.931	5083.026
22		0.000	252.042	252.042	30.962		-30.532	5365.600	5335.068	655.392	5083.026
23		0.000	252.042	252.042	28.148		-30.532	5365.600	5335.068	595.811	5083.026
24		0.000	252.042	252.042	25.589		-30.532	5365.600	5335.068	541.646	5083.026
25		0.000	252.042	252.042	23.262		-30.532	5365.600	5335.068	492.405	5083.026
26		0.000	252.042	252.042	21.148		-30.532	5365.600	5335.068	447.641	5083.026
27		0.000	252.042	252.042	19.225		-30.532	5365.600	5335.068	406.947	5083.026
28		0.000	252.042	252.042	17.477		-30.532	5365.600	5335.068	369.951	5083.026
29		0.000	252.042	252.042	15.888		-30.532	5365.600	5335.068	336.320	5083.026
30		0.000	186.050	186.050	10.662		-23.464	4004.540	3981.076	228.150	3795.026
31		0.000	186.050	186.050	9.693		-23.464	4004.540	3981.076	207.409	3795.026
Total	7225.492	0.000	6331.050	13526.542	6042.394	612.660	-763.301	134140.000	133989.359	29257.739	120462.917

Discount Rate 10.00%

Benefit 612.66

EBR 35.15%

B-C(Discount Rate=10%) 23487.911

B/C(Discount Rate=10%) 4.371

Table 10.2-3 Economic Evaluation

(Million Won)

	Costs					Benefits					
No. Year	Investmnet	Coal Cost	O&M Cost	Total Cost	Total Cost (N.P.V.)	Investment	O&M Cost	Fuel Cost	Total Benefit	Total Benefit (N.P.V.)	Benefits-Costs
1	150.531			150.531	136.846	15.317			15.317	13.921	-122.925
2	2436.346			2436.346	2013.509	247.893			247.893	204.874	-2122.635
3	1966.689			1966.689	1477.602	200.110			200.110	150.346	-1766.579
4	675.132			675.132	461.124	68.695			68.695	46.919	-606.437
5	645.778	0.000	79.190	724.969	450.149	65.703	-7.068	1361.060	1419.700	881.522	694.731
6	146.768	0.000	79.190	225.958	127.548	14.924	-7.068	1361.060	1368.926	772.723	1142.967
7		0.000	302.450	302.450	155.205		-30.532	5365.600	5335.068	2737.703	5032.618
8		0.000	302.450	302.450	141.095		-30.532	5365.600	5335.068	2488.349	5032.618
9		0.000	302.450	302.450	128.268		-30.532	5365.600	5335.068	2262.590	5032.618
10		0.000	302.450	302.450	116.608		-30.532	5365.600	5335.068	2056.900	5032.618
11		0.000	302.450	302.450	106.007		-30.532	5365.600	5335.068	1869.909	5032.618
12		0.000	302.450	302.450	96.370		-30.532	5365.600	5335.068	1699.917	5032.618
13		0.000	302.450	302.450	87.609		-30.532	5365.600	5335.068	1545.379	5032.618
14		0.000	302.450	302.450	79.645		-30.532	5365.600	5335.068	1404.890	5032.618
15		0.000	302.450	302.450	72.404		-30.532	5365.600	5335.068	1277.173	5032.618
16		0.000	302.450	302.450	65.822		-30.532	5365.600	5335.068	1161.066	5032.618
17		0.000	302.450	302.450	59.838		-30.532	5365.600	5335.068	1055.515	5032.618
18		0.000	302.450	302.450	54.398		-30.532	5365.600	5335.068	959.559	5032.618
19		0.000	302.450	302.450	49.453		-30.532	5365.600	5335.068	872.326	5032.618
20		0.000	302.450	302.450	44.957		-30.532	5365.600	5335.068	793.024	5032.618
21		0.000	302.450	302.450	40.870		-30.532	5365.600	5335.068	720.931	5032.618
22		0.000	302.450	302.450	37.155		-30.532	5365.600	5335.068	655.392	5032.618
23		0.000	302.450	302.450	33.777		-30.532	5365.600	5335.068	595.811	5032.618
24		0.000	302.450	302.450	30.706		-30.532	5365.600	5335.068	541.646	5032.618
25		0.000	302.450	302.450	27.915		-30.532	5365.600	5335.068	492.405	5032.618
26		0.000	302.450	302.450	25.377		-30.532	5365.600	5335.068	447.641	5032.618
27		0.000	302.450	302.450	23.070		-30.532	5365.600	5335.068	406.947	5032.618
28		0.000	302.450	302.450	20.973		-30.532	5365.600	5335.068	369.951	5032.618
29		0.000	302.450	302.450	19.066		-30.532	5365.600	5335.068	336.320	5032.618
30		0.000	223.260	223.260	12.795		-23.464	4004.540	3981.076	228.150	3757.816
31		0.000	223.260	223.260	11.632		-23.464	4004.540	3981.076	207.409	3757.816
Total	8021.243	0.000	7561.260	15582.503	6207.795	812.668	-763.301	134140.000	133989.359	29257.738	120406.855

Discount Rate 10.00%

Benefit 812.66

EDR 39.21%

B-C(Discount Rate=10%) 23048.944

B/C(Discount Rate=10%) 4.713

10.3 Socio-economic Influence

10.3.1 Outline

So far any certain method has not been established to evaluate socio-economic influence on macro basis by introduction of environmental equipment. It shall be pursued in the future.

In this chapter, the followings will be reported.

(1) History of introduction of environmental technology in Japan

(2) Some example of quantitative analysis on socio-economic influence by introduction of environmental countermeasure

(3) Report on influence by introduction of De-SOx system in Czech and Slovak Federal Republic from a certain aspect

We have learned from our experience that there are the following possibilities for benefits and losses generated from introduction of environmental equipment.

(Benefits)

- Reduction of disease of the nation
- Improvement of living, social and natural environment
- Economic growth and expansion of employment by investment for environmental equipment
- Decrease of the sum paid for the indemnity for healthy damage

(Losses)

- Rise of consumer price by addition of environmental cost and decrease of purchasing ability of the nation

10.3.2 History of Introduction of Environmental Equipment in Japan

Since Japan promoted economic recovery and expansion of the production after World War II, GNP recovered in 1955 (10 years after 1945) to the same as the

highest level before World War II. Average annual increase of GNP recorded 8.8% in the latter half of 1950's, 9.3% in the former half of 1960's and 12.4% in the latter half of 1960's. Since economic growth had been triggered by heavy chemical industry in which more environmental pollutant was discharged per unit production, environmental condition was getting worse in this period. However the portion of the investment for environmental protection in total capital investment of private sector was still low; around 3%.

Although some environmental laws were enacted after the latter half of 1950's, governmental position for environmental protection was still unclear at that period as seen in the example that such clause as "the harmony between environmental protection and sound economic growth" was stipulated in the laws. No governmental authorities existed for integrate administration in the field of environmental protection.

Environmental pollution expanded in around 1970 all over the country, and it became the most serious social problem. A total of 14 new environmental laws were enacted and the clause of "to protect the environment in harmony with economic growth" was deleted from Environmental Organic Law. The Environmental Agency was established for the integration of the environmental administration in 1971. Since that period the movement for environmental protection promoted rapidly.

10.3.3 Environmental Protection Technology in Electric Power Sector

In electric power sector regulations were prepared in 1970's as "Environmental Standard for Air Pollutant" including the standard for sulphur oxides effluent was enacted in 1974 and "Environmental Standard for Nitrogen Dioxides" in 1978. Equipments for environmental protection were also introduced from 1970's.

De-SOx systems were introduced for the oil fired power station from 1972 and for coal fired from 1975 : the first coal fired power station equipped with DeSOx was Takasago of EPDC. Since almost all the power stations for coal fired and oil fired with high sulphur fuel in Japan have been equipped with DeSOx at this stage, total number of power plants equipped with DeSOx are 68

units and 23,450 MW in operation and 6 units and 3,500 MW in construction. Almost all DeSOx are wet type.

De-NOx systems by the Selective Catalytic Reactor System were introduced from the latter half of 1970 and Takehara of EPDC installed DeNOx in 1982 for the first time as for the coal fired power station. At this moment all the thermal power stations situated at neighbouring big cities including oil fired, coal fired and gas firing are equipped with DeNOx : 122 units and 44,000 MW in total. As the result that the environmental standard in Japan is the most strict all over the world, Japan is the most advanced country in introduction of the DeSOx and DeNOx for thermal power stations and related technology in these field.

10.3.4 Examples of Estimate for Socio-economic Influence by Introduction of Environmental Countermeasure

In this section some examples of estimate for socio-economic influence by introduction of environmental countermeasures already studied in Japan, although a certain theoretical method has not yet been established for this purpose as before-mentioned.

(1) Comparison between the sum of damages from Environmental Pollution and the Cost incurred from Countermeasure for Environmental Protection

In a paper presented at the 1982 Tokyo conference of the Club of Rome, Professor Yoichi Kaya of the University of Tokyo offered a comparison between the amount of anti-pollution funds spent in one year to deal with sulphur oxides at their sources, such as plants, and the amount of damage estimated to result from pollution where there was a total lack of pollution countermeasures. This comparison was based on notably bold assumptions. As indicated by the tentatively calculated costs shown in Table 10.3-1, the total damage arising from the absence of anti-pollution measures (about ¥6 trillion, or $45 billion, annually in 1976 prices) far exceeded the estimated actual costs of anti-pollution measures (about ¥480 billion, or $3.7 billion, at 1976 prices).

(2) Tentative Statistics Relating to the Economic Impact of Anti-Pollution Investments

The impact on the economy of anti-pollution investments must be considered in terms of two major factors: namely, (1) the impact on prices, brought about by increased costs related to investments; and (2) the impact on income, induced by the increased demand for the anti-pollution products and services.

The first factor, the impact on prices, would vary according to the supply-demand relationship of the specific products. Nonetheless, cost increases due to investments in pollution control will have an effect on the prices of the particular products concerned. This, in turn, will affect the prices of the products consumed by the industries that manufacture goods using the particular products or parts in question as raw materials. This, furthermore, will affect the prices of the end consumer goods. When these prices rise, the demand for the various consumer goods will decline according to their price elasticities (rates of changes in demand according to price changes). This will result in a decrease in investment in plant and equipment in each industry, which in turn will lower its supply capacity.

The second factor, the impact on income will be that anti-pollution investments will become part of the cost of the industries making the investments, and at the same time will increase the demand for the products and services of the industries that receive the investments. Furthermore, the increased demand in the anti-pollution industries will expand the demand for materials and parts needed in investments relating to those industries, and will constitute a factor promoting investments in related industries and their capacity for supply.

As we have seen above, the effect of the first factor is to reduce the real GNP (i.e. price effect) and the second factor is to expand the real GNP (i.e. income effect).

The *Environment White Book* published in 1977 by Japanese Government focuses on these two effects and offers tentative statistics relating

to the macroeconomic impact produced by the environmental measures taken during the decade between 1965 and 1975.

According to this document, the total private-sector investment in anti-pollution measures during this period was ¥5.3 trillion (about $40 billion at 1970 prices). The following estimates for some economic indices were shown as the effect of the investment for the environmental equipment compared with the case where such investment had not been carried out.

Effect of Investment for Environmental Equipment

• Good Effect

Real GNP	0.9% Increase
Real Consumption	0.4% Increase
Real Investment of Private Sector	7.4% Increase

• Adverse Effect

International Balance of Payment	300×10^9 yen (2.2×10^9 US dollars) Decrease of Profit
Consumer's Price	1.2% Increase
Wholesaling Price	1.7% Increase

Real GNP is estimated to have been somewhat larger than when anti-pollution measures had not been carried out. Thus, the analysis shows the enforcement of rigorous counter-pollution measures had little ill effect on the macroeconomy of the nation.

Other nations have had similar experiences. As the OECD says, "The effect of anti-pollution investments on GNPs ranges from 'neutral' to 'negligible'." (See "*The State of the Environment*", OECD; 1991).

Table 10.3-2 shows tentative calculations of the economic impact of anti-pollution measures.

10.3.5 Socio-economic Influence in Czech and Slovak Federal Republic

Based on the data and analysis abovementioned, socio-economic influence of the introduction of environmental protection technology such as DeSOx in Czech and Slovak Federal Republic on macro national economy will be estimated as follows:

(1) GNP Growth and Expansion of Employment by Investment

It is recommended in this Report that the Project shall be implemented as much as possible inside Czech and Slovak Federal Republic including procurement and construction works. If the Project is materialized in such a manner, it will have much good influence on Czechoslovak economy by GNP growth and expansion of employment. It will be brought by procurement and distribution of materials, construction works and operation and maintenance of the DeSOx system by companies and organizations inside Czech and Slovak Federal Republic.

(2) Influence on electricity tariff will be absorbable.

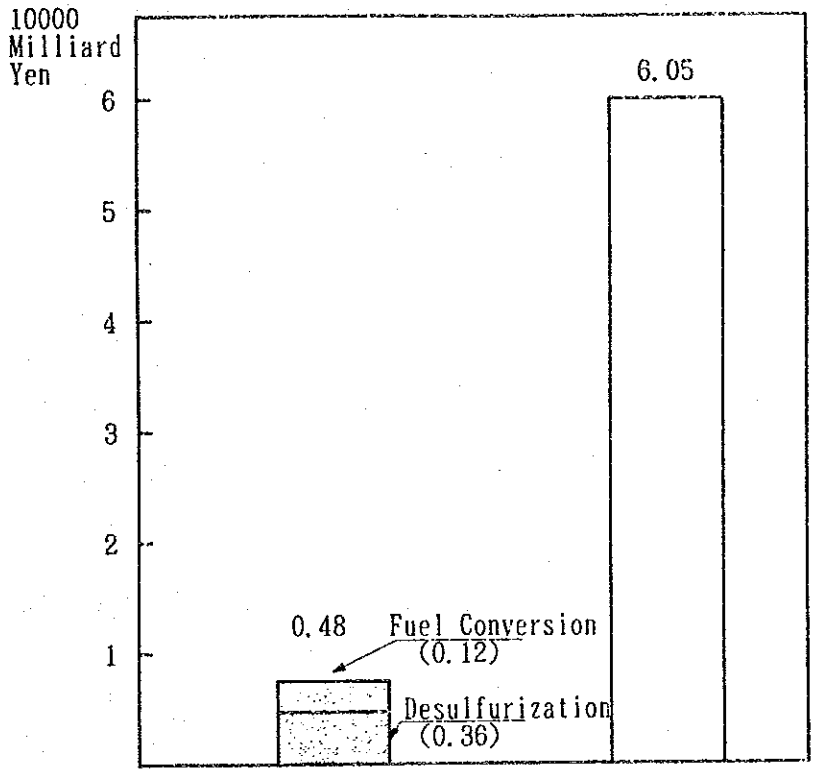
Although investment for DeSOx system shall be returned by electricity tariff, it is estimated that the rise in tariff will not be so much and tariff level will be getting less every year by the reduction of unamortized assets for this Project as shown in this Report before. In addition, since Czechoslovak government is now starting the works on revision of the electricity tariff system from governmental subsidy basis to actual cost basis, it is thought not so difficult to include necessary environmental cost such as the cost for this Project in new electricity tariff system to be executed in near future.

(3) Expectation for Export Market

It is thought to take not so long period for Czechoslovak companies and organizations to catch up with the current technology level for the production and operation of DeSOx system, judging from the present level of Czechoslovak technology. Market for DeSOx system for coal fired power stations around Czech and Slovak Federal Republic will be getting larger including USSR, east European countries as well as OECD

countries such as Germany on the background of the global environmental dispute. Therefore, environmental protection industries such as DeSOx system can be cultivated as one of the main exporting industries in Czech and Slovak Federal Republic in near future by taking advantage of technology and cost competitiveness.

Table 10.3-1 Comparison between Actual Cost for Countermeasure for Desulphurisation and Conceivable Damages if no Countermeasure were made



(1) Actual Cost

1) Conversion of Fuel

Cost up by the increase of the portion of low sulphur oil in total primary energy consumption between 1976 and 1965.

2) Desulphurisation

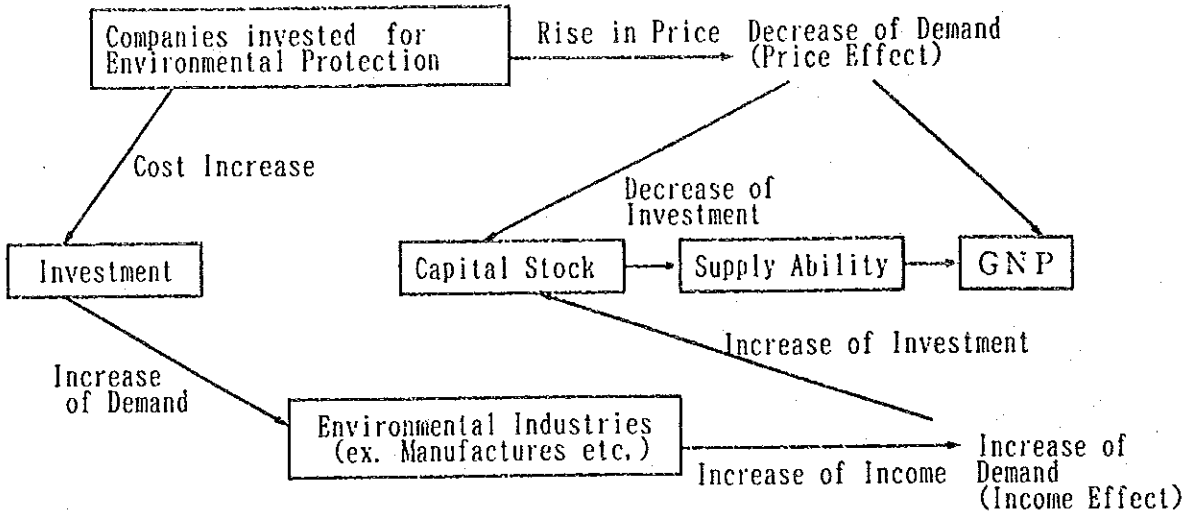
Depreciation and Running Cost of averaged DeSOx equipment x actual units installed from 1965 to 1976

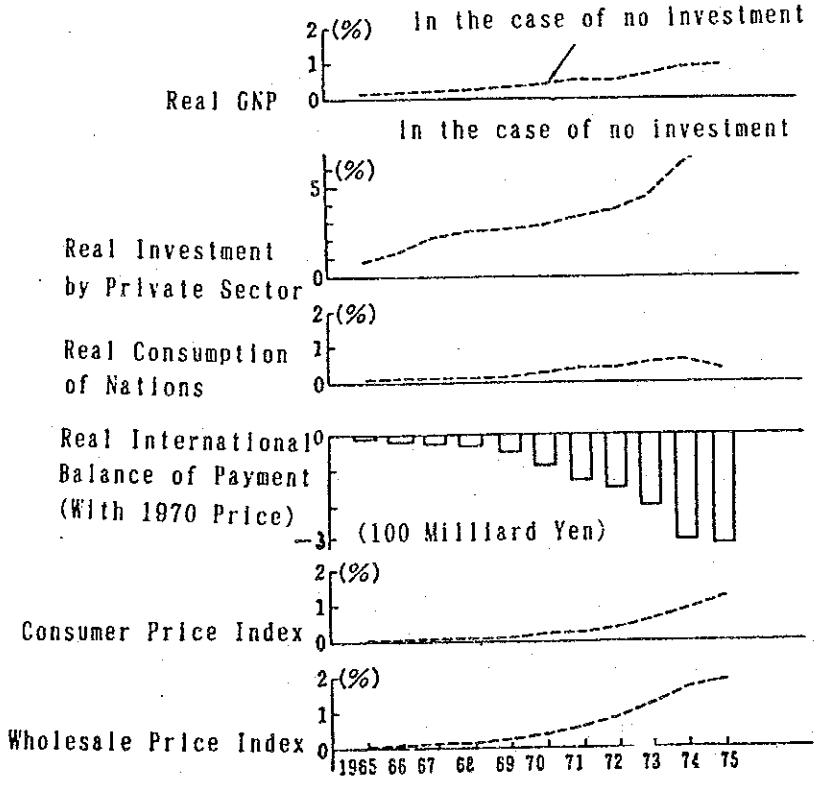
(2) Conceivable Damages

Indemnity for Environmental Disease per a patient x Number of Conceivable Patients in 1976 if no environmental countermeasure were made.

Ref: Report by Yoichi Kaya

Table 10.3-2 Effect of Investment for Environmental Protection by Private Section on Macro Economy





Ref: Environmental White Paper of Japanese Government

JICA