(3) Specific Description of ABC Improvement Plan

a. Plan 1

a) Static characteristics test

The purpose of the test is to find out the gain of the feedforward control system of ABC by grasping all the input figures of the boiler corresponding to the MW output of the plant at maximum, and at each lower load with 3 or 4 steps of equal MW intervals.

The result of the test shall be expressed in the balanced diagram of plant load versus boiler inputs, which eventually determine the aforementioned control system gain.

b) Characteristics test of input/output of boiler input actuators

This test is conducted for the purpose of confirming the linearity of the input/output charactristics of the boiler input actuators in between high and low load range of the plant. And if their characteristics are found to be non-linear, control system gain will be adjusted accordingly. Normally, function generators are applied to obtain the linearity of the actuator control system.

c) Measurement of input/output characteristics of ABC module

This measurement is made at the same time when the above mentioned static characteristics test and boiler input actuator test are conducted, to decide the actual control gain of ABC system and to predict the amplitude of compensation of minor control loop.

Therefore, high impedance type digital meters are necessary since the measurement will be made at the voltage terminal of each control module.

d) Adjustment and testing

At first, each control module will be tentatively adjusted at the gain of feedforward control loop of ABC system and at the amplitude of compensation determined by the previous tests. In this case the unit must be shutdown for a while in principle, however, as long as the adjustment will be within limited range, it can be done during the plant operation. The following staffs are necessary for the adjustment and testing at least.

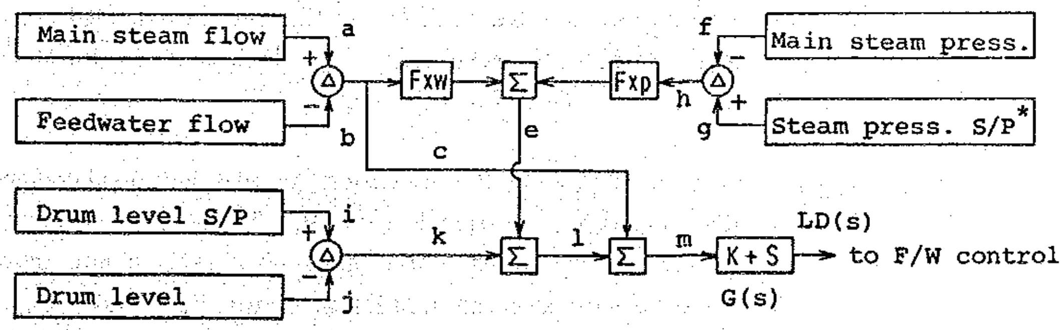
Planning and supervision of adjustment and testing	.... 1 person
Assistant for the above	.... 1 person
Engineer from ABC manufacturer	.... 1 person
Ancillaries	.... 2 persons

Secondly, load variation test will be carried out. This test will be conducted for the confirmation of the stable main steam pressure and temperature based on the normal follow up of such boiler inputs as fuel, water and air in response to the change in the generator output regulated by the changes in the turbine governing valve.

On the other hand, as well as confirming the normal combustion condition, it should be acknowledged that boiler master is well adjusted to maintain proper O_2 value at respective load without automatic O_2 control.

In the last, a test shall be conducted to examine the maximum load change rate allowable to the ABC system with the modification of Plan 1.

b. Plan 2



Note: S/P (Set Point)

Fig. 8-3 Ideal Control System

a) Detailed site survey must be carried out to clarify the modifications to improve the existing feedwater control system up to the ideal one shown in Fig. 8-3 above.

The objective of the survey is to identify the modification items to change the existing cascaded control system into one loop control system driven by resultant error of drum level and feedwater flow. And, for the purpose of eliminating the effect of the negative response in drum level, function generators will be added.

b) Basic design for the new control system to be described in the technical specifications of bidding document must be carried out by consultant and the detailed design of the actual works shall be done by the conractor.

c) The adjustment test is to be conducted in the same procedure as described for Plan 1.

c. Plan 3

Plan 3 must be considered on condition that improvement of Plan 1 and 2 are already applied. The purpose of Plan 3 is to improve the MW control system in the ABC coordinated control system. The portion to be improved and corresponding measures are described in the following.

For the MW control system in Fig. 8-4:

a) In the existing system, the load demand from LMCC is directly transmitted to the turbine governing valve actuator and the valve position signal is fed back to set the valve at expected position, however, function generator (F_{XL}) is needed to transfer the valve position signal into MW signal.

b) In order to equalize the dimension of signals with load demand of MW dimension, the signals from the first stage pressure of the turbine and generator output must be converted into those of MW dimension adopting function generators F_{XSP} and F_{XMW}.

By the above means, as the change in the valve position, the first

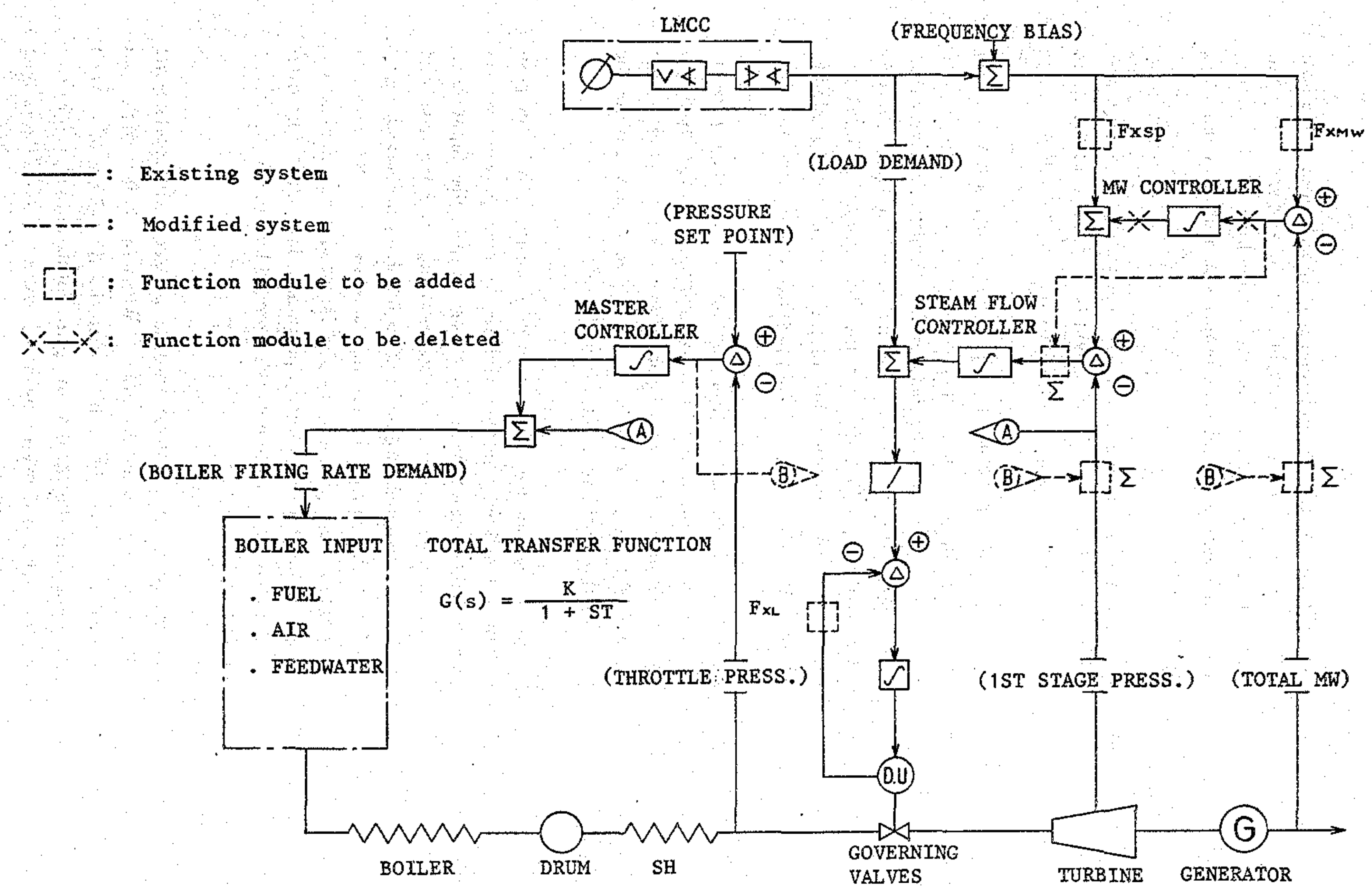


Fig. 8-4 Improvement of Coordinate Control System of MW Control

stage pressure of turbine and total MW versus those in the load demand signal becomes to have same gain, the load can be changed with zero control deviation in the closed loop of the control system of steam flow and MW, resulting in a highly stable plant control system.

c) As a countermeasure which enables higher control stability, MW controller will be cut off and it will be connected to the steam flow controller to add the error signals of both controllers.

These two control systems have just the same transfer gain and phase lag versus the change in the governing valve position, and one of them can actually be removed for simplification. However, to maximize the use of the existing control module, the MW error is directly transmitted to the steam flow controller by-passing the MW controller in order to eliminate the possibility of oscillation caused by cascaded integrated control system.

d) Correction of the signals from the turbine first stage pressure and generator output for the coordination of boiler input and turbine output by the error signal between set pressure of main steam and turbine throttle pressure can eventually enables the compensation of the time delay in boiler output.

When the load increase signal is given from the LMCC, the position of turbine governing valve and the first stage pressure changes correspondingly resulting in the change in the boiler input, however, the thermal energy of the steam at the governing valve inlet does not immediately respond due to the delay in thermal energy transfer in the boiler. Therefore, the governing valve moves to the position corresponding to the intended load entailing the change in the turbine throttle pressure. This means the overriding of the valve position of the intended load under the normal pressure.

The change in the turbine throttle pressure will regulate the boiler input by master controller. When the boiler catches up the load change of the turbine after the time delay of thermal energy transfer, the throttle pressure will be normal, and due to the aforementioned overriding of the valve position, the turbine output will be over or under the magnitude intended.

To correct that overshoot or undershoot of the turbine output, MW & steam flow control systems will regulate the governing valve again. At the same time the first stage pressure of the turbine and the boiler input demand will change the boiler input accordingly.

Thus, the continuous hunting of plant input/output will be caused due to the process above-mentioned. This is the specific feature of the closed control loop of the turbine and boiler coordinated each other by means of the signal of the first stage pressure of the turbine.

As the countermeasure for this hunting problem, it is necessary to apply the signal in the negative manner of the change in the throttle pressure corresponding to the load change to the feed-back signal of the turbine/generator output to maintain the governing valve at the right position corresponding to the load demand signal from LMC and to have constant boiler input demand (after correction). In other words, the turbine is operated under the turbine follow mode with the constant governing valve position until the boiler will catch up the load demand.

8-2-2 Improvmeent of Other Monitoring/Control System

(1) Flue Gas O_2 Meter

Three units out of four are out of order. Orsat analysis carried out this time during the combustion test showed large imbalance of O_2 between A and B flue gas duct. As O_2 analyzer is one of the most important instrument for combustion management, procurement of spare parts for repair work or replacement is urgently needed. Traverse of the gas duct to locate the O_2 probe at right position is also necessary.

(2) Improvement of Flame Monitoring System

There are some problems in the logic of the flame monitoring system.

- Once flame out is detected by flame detector the flame out signal will not be reset for 15 seconds even the flame recovers earlier.

- Even after the one mill trip, flame out signal of the burners of tripped mill still remains.

Therefore, the following modifications of logic circuit of the flame detector are recommended to prevent erratic tripping of the plant.

- Flame out detection signal will be cancelled right after the recovery of the burner flame.

- If one of the mill trips out, the flame out signals corresponding to that mill will be separated from the critical flame out logic.

(3) Calibration of Monitoring Instrument

O_2 meter, draft gauge, thermometer (steam, water, gas, air, oil, etc.) level gauge, etc., must be calibrated and defective ones must be replaced.

(4) Countercheck of Measured Values

Discrepancy of indications between indicator and recorder, controller and data logger, data logger and CRT display, etc., which are giving complication for right judgement on plant operation, should be counterchecked, adjusted and/ or repaired accordingly.

(5) Position Indicators

Discrepancies were also found between the actual position and outside indicator of air register of the burners, classifier vane of the coal mill, etc. Position indicators of the air register fitted in the central control room are also out of order. Urgent repair and adjustment of the above are also recommended.

8-3 Environmental Protection

8-3-1 Environmental Monitoring

The environmental protection manual has been prepared in Calaca power plant, and observance of emission standard and operation of environmental protection equipment are carried out. Environmental value are measured periodically, however, the following recommendations, are listed up.

(1) Though measurement of dust in the air is carried out around the power plant, it is affected by dust from the road. It is desired that the measurement will be made at the border line of the power plant compound for the investigation of the influence by the power plant.

(2) For measurement of effluent water quality, it is desired that measured data is arranged and sorted. And for measurement of trace quantity of toxic substances, it is desired that the detection limit is clarified. Though atomic absorption photometer for measurement of water quality is installed, this equipment can not be used because that necessary gas, hollow cathode lamps, etc. are not delivered yet. It is desired to procure necessary parts and to carry out the measurement.

(3) Though the noise measurement is carried out around the power plant, it is desired that the noise level is measured at the border line of the power plant compound for the investigation of influence by the power plant. As the regulation specifies the cyclic measurement by time bands such as morning, daytime, evening and nighttime, the measurement according to the regulation is desired.

(4) The meteorological station is provided in the power plant where the wind velocity, wind direction, temperature and relative humidity are measured in the station. The meteorological survey is required for Unit No. 2 expansion plan but some of measuring equipment are out of order at present, therefore, necessary data can not be obtained. Observation data is as shown on Table 8-7. The ordered spare parts for the repair of meteorological instruments are as shown in item 6 on Table 8-8 and urgent maintenance for the equipment is desired.

8-3-2 Preventive Measures against Coal Dust from Coal Yard

When the coal unloading and coal handling facilities are in operation, much coal dust flies and deposits around the unloaders and coal yard.

The coal dust influences the equipment around the powerhouse and the private houses near the power plant seriously when the wind direction is unfavorable.

(1) Countermeasure for Unloader Coal Dust

Water spraying (Jet washing) facilities and dust suppressing plates will be installed as preventive measures against coal dust from unloader.

Table 8-7 Meteorological Data (Monthly Average)

CY	Month	Wind Speed km/h		Temperature °C		Relative Humidity	Prevailing Wind Direction	
		100 m	10 m	100 m	10 m		100 m	10 m
1986	January	45.93	5.44	24.01	23.48	63.11	Not measured due to defective sensor	ENE
	February	36.44	18.48	24.91	23.85	67.28		ENE
	March	41.72	20.34	Not measured due to defective sensor	24.93	62.28		ENE
	April	41.46	22.33		26.49	62.48		ENE
	May	25.26	12.50		26.87	70.95		SW
	June	18.58	10.52		27.87	69.61		WSW
	July	23.80	11.58		25.47	69.23		SSW
	August	33.95	16.58		25.58	92.02		WSW
	September	25.92	9.65		25.27	Not measured due to defective sensor		WSW
	October	28.14	11.31		25.08			SE
	November	28.60	11.16		25.17			ESE
	December	37.84	14.23		24.18			ENE
1987	January	44.34	17.91		25.59			NE
	February	42.30	15.48		23.35			ENE
	March	41.50	15.53		25.29			ESE
	April	31.89	13.31		26.98			ESE
	May	22.04	9.92		28.15			SE/SSE
	June	27.27	12.58		26.98			SSW

Table 8-8 Procurement of Materials & Chemicals

Laboratory Equipment

1. Weighing balance

2. Acetylene gas ┐
   ├ for AAS (Atomic Absorption Spectro Photometer)
3. Nitron oxide gas ┘

4. Hollow cathode lamps for AAS

5. Control board assembly IL 76218 Rev. 6 Model IL 257 for AAS

6. Meteorological instrument sensors:
   a. Temperature sensor AD 590 JAL
   b. Relative humidity sensor Hanicap 6061 HM Vaisala
   c. Potentiometer 10 K wind direction – Type C units

7. Laboratory refrigerator

8. pH combination electrode type N 424 Schott Gerote or equivalent

(2) Countermeasures against Coal Dust

a. The coal dust flying from the coal yard influences private houses in the surrounding areas and the power plant equipment, and it is necessary to give proper countermeasures.

b. The coal yard is located about 200 to 300 m far from the facilities and private houses outside the power plant compound.

As shown in Fig. 8-5, most of the dust particles larger than 200 μm fall down within the power plant compound even at the time of strong wind, and the coal dust influencing the surrounding areas is of particles sizes smaller than 200 μm.

The flying coal dust contains practically no particles smaller than 10 μm, which are regarded as the suspended particulate matter, as shown in Fig. 8-6, and even if such minute particles are contained, they tend to be dispersed over a wide range of 500–3,000 m or more, and their effect can be neglected.

Thus, coal dust of sizes ranging 10–200 μm needs to be considered in the countemeasure.

Generally, coal containing grains of 3 mm or smaller in more than 40% is liable to generate flying dust, and Semirara coal is classified as the kind liable to generate flying dust.

c. There are two types of flying dust originating from the coal handling equipment and the coal yard.

The one is the dust caused by the operation of the unloaders, stackers, reclaimers and such coal handling equipment, and the other is the dust rising from coal piles in the strong wind.

The countermeasures against each type of the flying dust are described in the following.

a) Countermeasures against flying dust from coal handling equipment

i. The unloader hoppers will be provided with windbreak covers and water spray (jet washing) devices.

ii. The stacker/reclaimers will be provided with water spray devices, which can be used also for prevention of clogging of the bucket.

iii. The reclaimer hoppers will be provided with wind break covers and water spray devices.

iv. The operating method will be improved for suppression of flying dust, namely, height of drop of coal will be made as short as possible.

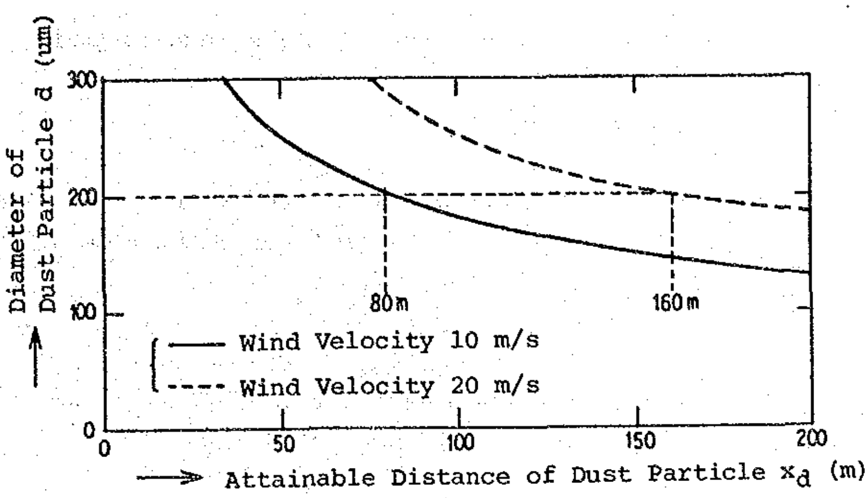


Fig. 8-5 Diameter vs. Attainable Distance of Dust Particle generated at 15 m in height

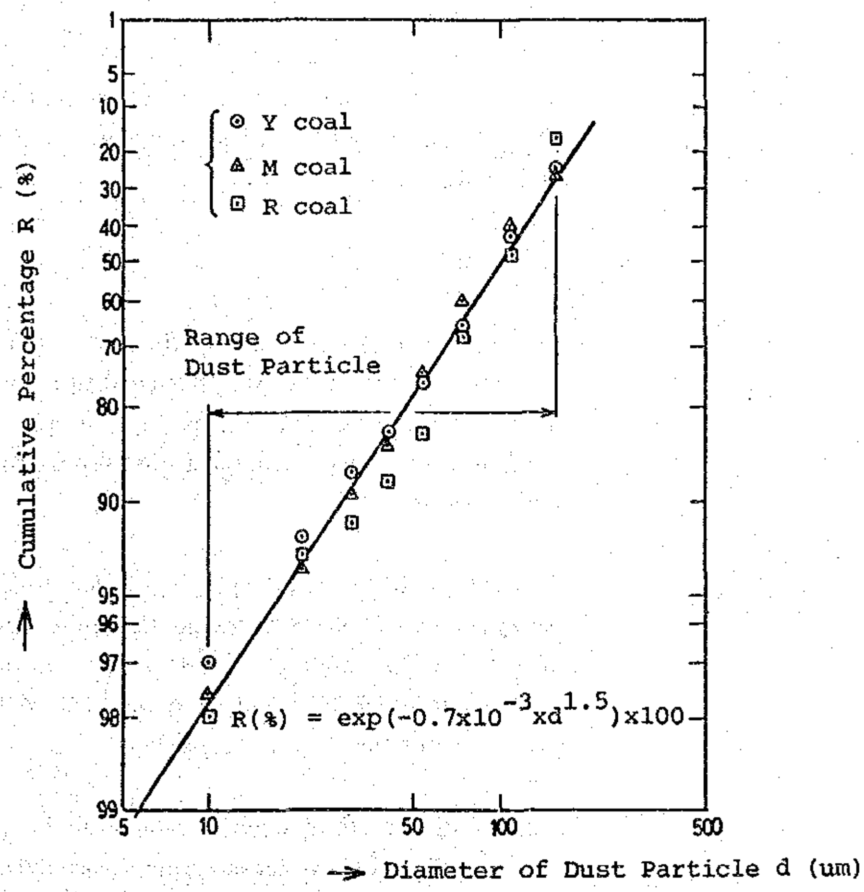


Fig. 8-6 Distribution of Flying Coal Dust Particle Diameter

b) Countermeasures against flying dust from coal yard

i. Windbreak fence

A windbreak fence will be installed to the windward of the coal yard to cover the whole length of the coal piles against the NE wind, as shown in Fig. 8-7.

The windbreak fence will have the effect of reducing the wind velocity by more than 50%, and the effect will extend leeward over 10 times the height of the fence.

ii. Water spraying over coal piles

The existing water spray system will be reinforced, and the flying dust will be suppressed by wetting of the surfaces of coal piles.

Generally, the wind velocity at which coal dust begins to fly gets higher as the surface moisture increases, as shown in Fig. 8-8.

iii. Spray of surfactant

In case where the drying of the surface of coal piles is extremely quick due to weather conditions or the coal pile is held for a long time, the method of spraying some surfactant which has long lasting dust suppressing effect, can be considered.

For this, addition of the spraying device utilizing the water spray system is necessary, and the spray device will cost about Yen 300 million for use of the consolidating agent and water repellent agent, and the cost of the chemicals will be about Yen 15 million per year.

This coating method would be effective in case where the wetting of coal by water spraying causes clogging troubles, but the example for the lignite has not been confirmed and the adaptability should be carefully confirmed prior to its adoption.

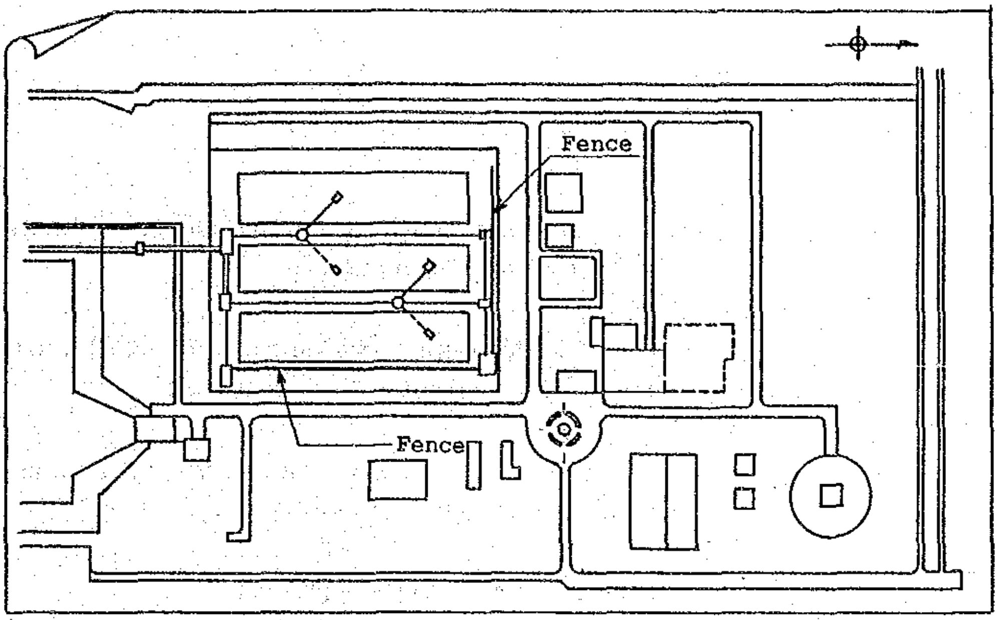


Fig. 8-7 Layout Plan of Windbreak Fence

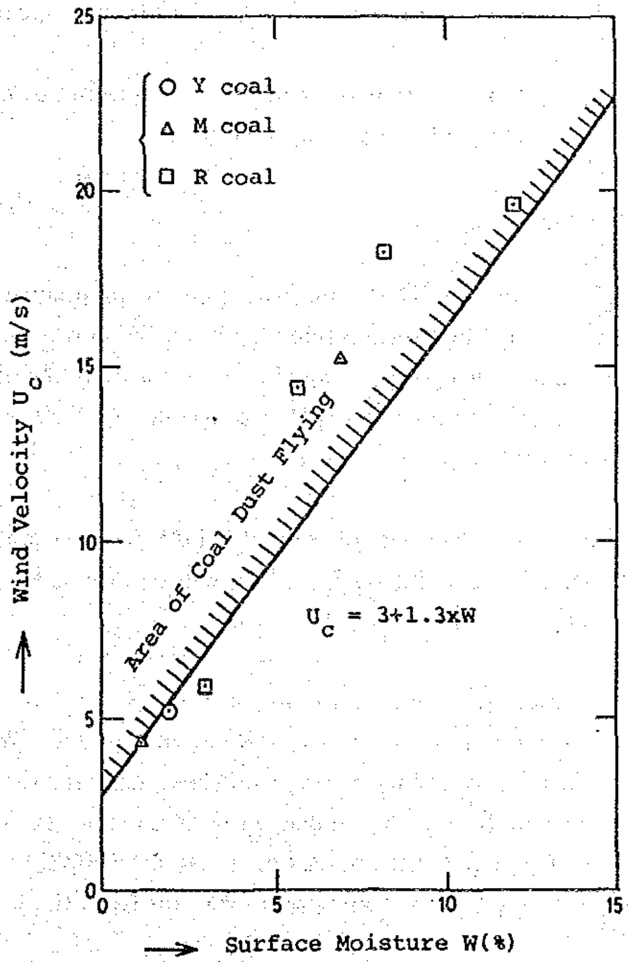


Fig. 8-8 Wind Velocity to Generate Flying Dust

iv. Water curtain

The method of providing a water curtain to the leeward of the coal yard is conceivable.

However, this method had no record of actual installation and the effect has not yet been confirmed.

And there is a possibility of secondary pollution, in particular environmental situations.

v. Suppression of dust by compression

Suppression of dust by compression with bulldozers is conceivable, but it may require big operating cost, and the dust suppressing effect may not be very great.

It is said that the spontaneous ignition can not be prevented completely by compression.

8-3-3 Pollution of Groundwater

Work of environmental division is the measurement of air quality, water quality, noise, etc., and settlement of complaints from residents around the power plant. At present, residents of resettlement area near ash pond, complain about unsuitability of drinking water by presence of salt in well water. Conductivity, pH and chlorine (Cl^-) are measured periodically in relation to the above complaint.

Assuming households of 255 and population of 2,000, it is estimated that 20% of those, namely households of 55 and population of 440, will be affected by the well water contamination.

Area affected by seawater contamination is Block 2 and 3 faced to ash disposal area and Block 7 and 11 near the meteorological tower. (Refer to Fig. 8-9.) Water tight lining system is which ground surface is covered by water proof sheet, has been developed recently as the countermeasures for groundwater contamination with seawater, the cost, however, is \$2,900 (¥400,000)/100 m^2 (objective ash disposal area: about 500,000 m^2). Therefore, large amount of cost is necessary to give complete prevention from the groundwater contamination.

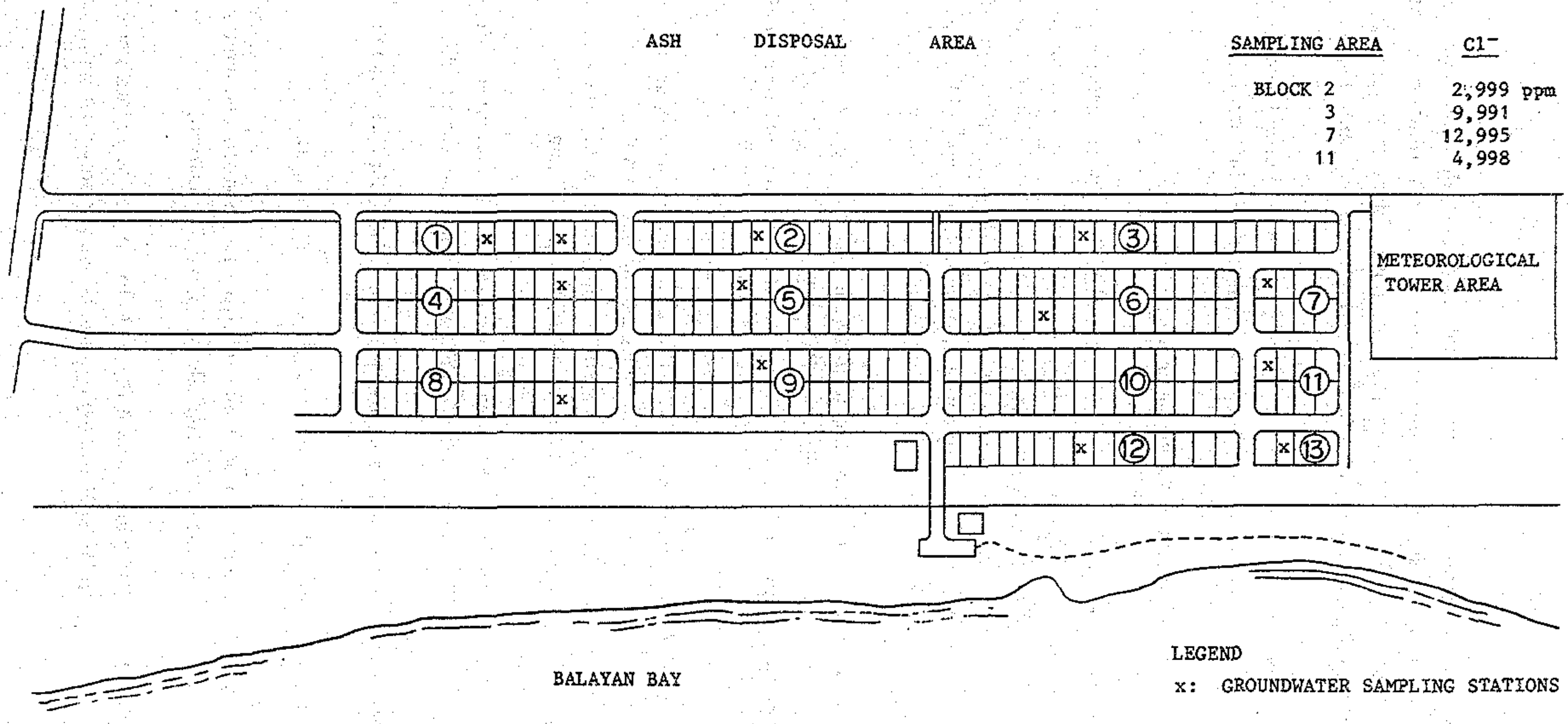


Fig. 8-9 Groundwater Contamination with Seawater

As the countermeasure for the groundwater contamination around the power plant, installation of water supply facilities (clarifier of 30 t/h, filter, tank, chlorine injection facilities, water transfer facilities, etc.) in the power plant to supply water will be better choice comparing with the direct works in ash disposal area described above.

The countermeasure of the groundwater contamination will be carried out in connection with the development plan of Unit No. 2 which is now in progress.

8-4 Coal Unloading and Handling Facilities

In both cases of the use of ROM coal and SSC, many problems were encountered on the coal unloading and handling facilities. Namely in the case of ROM coal, coal sticking, clogging, and coal dropping happened at many parts of the facilities, especially, plant trips caused by clogging in relation to the coal mills were frequent. In the case of SSC, the situation could be improved to some extent, but such problems are still left unsolved as clogging by high moisture coal, flying coal dust, spontaneous combustion, etc.

Coal unloading and handling facilities in the coal storage yard will be modified depending on the application plan of ROM coal and SSC for Unit No. 2 expansion. The following studies for improvement plan and future operational plan of the facilities are carried out.

Regarding the modification for ROM coal use, it is advisable that further tests and experiments will be conducted at the time coal samples from Panian and Himalian are available for better assessment on the extent of modification necessary for th existing coal handling facilities putting more emphasis on ROM coal handling.

* Note: Details of studies are described in the Preliminary Report on the Coal Unloading and Handling Facilities already submitted.

8-4-1 Improvement Plan and Measures for Handling of ROM Coal and SSC

(1) Preventive Measures for Coal Sticking and Clogging

a. Asymmetrical shapes of coal silos, hoppers and chutes will be adopted and the size of coal silo outlet will be enlarged.

b. The plant parts of the coal silo will be covered with new lining materials, Hi-Moler (Ultra-high molecular weight polyethylene).

c. High pressure water jet washing device will be provided for the bucket of reclaimers, crusher screens, etc.

(2) Preventive Measures for Coal Slippage on Belt Conveyor

Water draining device will be equipped for drainage of standing water after rain on the belt conveyors and for prevention of coal slippage on conveyors.

Conveyors B-1 and B-2 will be made reversible for draining of standing water.

(3) Preventive Measures for Coal Dropping

It is presumed that the coal dropping from conveyors is due to overload. Therefore, the necessary indicators are to be provided for proper load operation to avoid overloading.

(4) Preventive Measures for Coal Dust

a. Water sprays and dust suppressing plates will be fitted on the unloader hoppers.

b. Water spray system will be provided on the stackers/reclaimers.

c. Windbreak fences will be installed for coal yard. And water sprinklers will be expanded.

d. Vacuum cleaners will be equipped in the coal transfer towers and regular cleaning shall be carried out.

e. Sealing works of the top of the coal silos in relation to the tripper operation in the bunker room will be carried out.

(5) Preventive Measures of Presence of Foreign Materials in Coal

Two magnetic separators will be added on the coal receiving line.

(6) Preventive Measures for Spontaneous Combustion

a. Water sprinklers will be expanded.

b. Temperature measuring for each piles shall be carried out.

(7) Improvement of Blending Accuracy

a. Coal blending facility will be installed in the coal yard, and accurate blending will be carried out. Outline of the facilities is shown in Fig. 8-10.

b. As an alternative of coal blending facility, improvement of dispensing coal scales and automation of reclaiming system of reclaimers can be conceived however, the blending accuracy is a little lower than that by blending facility even though it is much higher than present.

At present, dispensing coal quantity is adjusted by manual operation reading the existing coal scale. The existing scale will be changed to accurate coal scale (with compensation for the change in boom inclination). The new scale will be linked with sequencer and inching of bucket by each half cycle of boom travel will be adjusted automatically. Thus, coal reclaiming control system will be automated to dispense the designated constant volume of coal.

(8) Management of As Received Coal Quality

Repair of received coal scale and auto-sampler will be carried out and confirmation of contracted coal quality will be done.

(9) Management of As Fired Coal Quality

For analysis of as fired coal and improvement for more accurate performance control existing manual sampler will be converted to autosampler with primary reduction system of coal. And existing dispensing coal scale will be repaired.

8-4-2 Improvement of Coal Handling Facilities Corresponding to Coal Operation Plan

Improvement of coal handling facilities are provided as common facilities for Unit No. 1 and 2 taking the future plan into consideration.

The following four cases are studied.

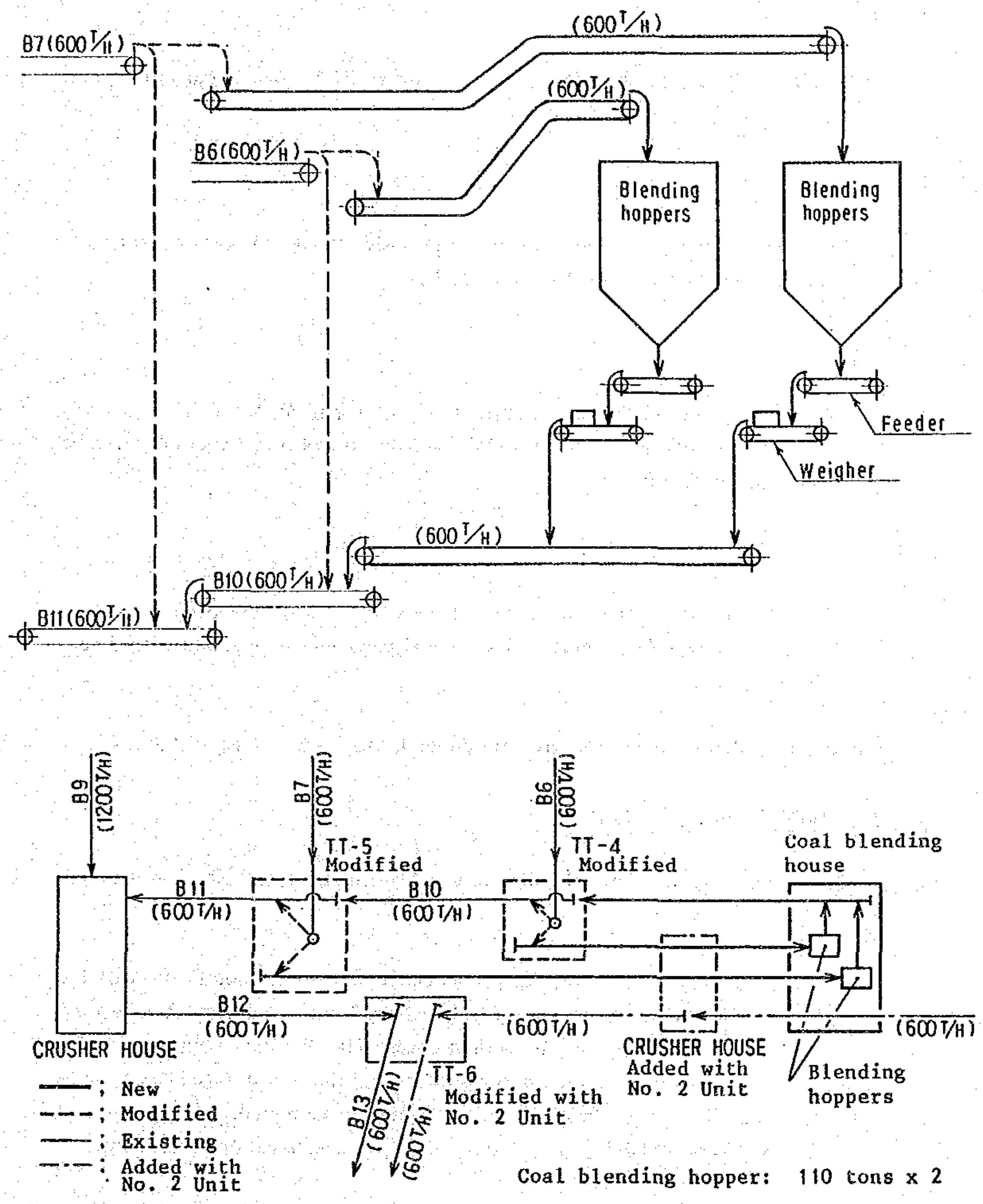


Fig. 8-10 Improvement Plan of Coal Blending

Case 1:

Both No. 1 and No. 2 boilers will fire exclusive ROM coal. (Coal yard will be operated with 3 coal piles as it is.)

Case 2:

Both No. 1 and No. 2 boilers will fire exclusive ROM coal. (Two additional coal piles will be expanded for Unit No. 2.)

Case 3:

No. 1 boiler will fire the coal of current use. (SSC and AC blended)
No. 2 boiler will fire exclusive ROM coal. (Two additional coal piles will be expanded for Unit No. 2.)

Case 4:

No. 1 boiler will fire the coal of current use. (SSC and AC blended)
No. 2 boiler will fire exclusive SSC. (Coal yard will be operated with 3 coal piles as it is.)

Comparative studies on the above cases are shown in the following Table 8-9.

(1) Study Results and Evaluation

a. The Case 1 shows the plan in which both No. 1 and No. 2 boilers will fire ROM coal.

This case requires the largest scope (and cost) of modification of the existing facilities for use of ROM coal and is uneconomical. And further, the coal storage capacity would cover only 19.7 days consumption for No. 1 and No. 2 units, posing problems in the coal storage management, and the power plant operation would be hampered. (Long pause of Semirara coal delivery is 25 days on an average, based on past record.)

This case will be compatible only with the new construction of another boiler for Calaca Unit No. 1 to replace the existing one and will not be realistic in this point of view.

Table 8-9 Comparative Study of Coal Handling System for ROM Coal Firing (1/6)

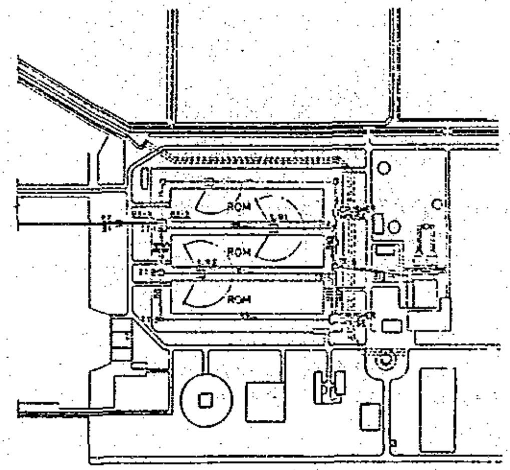
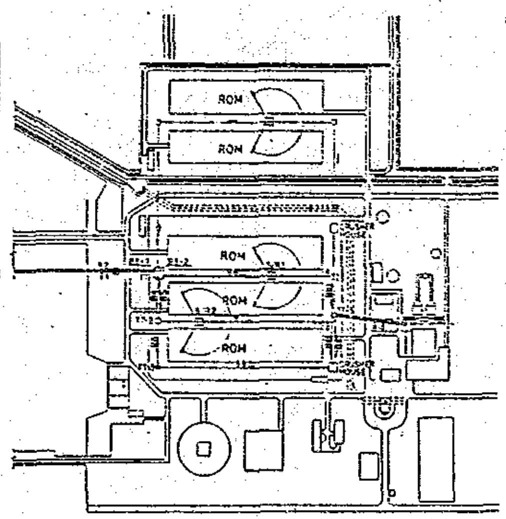
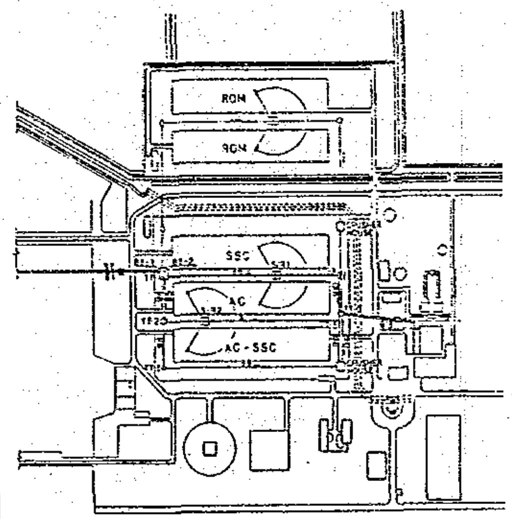
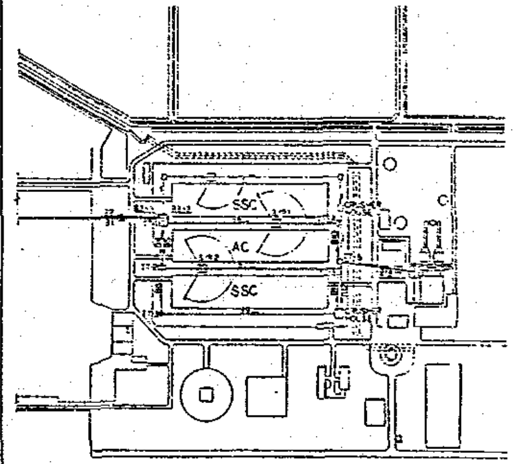
	Case 1	Case 2	Case 3	Case 4
	ROM Coal Firing for No. 1 and No. 2 Units		Blended SSC with Australian Coal Firing for No. 1 Unit and ROM Coal Firing for No. 2 Unit	Blended SSC with Australian Coal Firing for No. 1 Unit and SSC Coal Firing for No. 2 Unit
Schematic System Diagram	 Coal yard not expanded (3-pile operation)	 Two coal piles added for No. 2 unit	 Two coal piles added for No. 2 unit	 Coal yard not expanded (3-pile operation)

Table 8-9 Comparative Study of Coal Handling System for ROM Coal Firing (2/6)

		Case 1	Case 2	Case 3	Case 4
		ROM Coal Firing for No. 1 and No. 2 Units		Blended SSC with Australian Coal Firing for No. 1 Unit and ROM Coal Firing for No. 2 Unit	Blended SSC with Australian Coal Firing for No. 1 Unit and SSC Coal Firing for No. 2 Unit
Coal Yard Existing coal yard was designed for 45 days operation. - Plant capacity : 300 MW x 2 u - Calorific value of coal : 4,722 kcal/kg - Plant efficiency: 39% - Plant factor : 70%		- With 30° angle of repose, the storage capacity of the existing coal yard becomes 165,600 tons (19.7 days coal for 300 MW x 2 units). - Storage capacity decreases greatly, and operation of the power plant would be hampered. The average interval of long pause of Semirara coal delivery since April 1985 is about 25 days.	- With 30° angle of repose, the storage capacity of the existing coal yard becomes 165,600 tons (19.7 days coal for 300 MW x 2 units). - 45 days coal storage can not be obtained including additional two coal piles.	- The existing coal yard will store Semirara SSC and Australian coal as it does now. One coal pile out of the 3 will be used for storing SSC and AC for emergency use for No. 1 and No. 2 Units.	- With 30° angle of repose, the storage capacity of the exisitng coal yard becomes 165,600 tons (20.1 days coal for 300 MW x 2 units) - Storage capacity decreases greatly, countermeasures for the plant operation will be required. - The average interval of long pause of Semirara coal delivery since April 1985 is about 25 days.
	Modification of existing facilities	None Measures to be taken when No. 2 Unit is added.	Same as left.	- If the coal-blending accuracy is to be improved a coal-blending facility would be added.	Same as left.
	Modification cost for existing facilities	None	Same as left.	[$5,143,000]	[$5,143,000]
	Works to be done at No. 2 Unit addition	- One track will be added at the time of No. 2 Unit addition for 1 additional unit of stacker/reclaimer.	- Two-pile coal yard for No. 2 Unit will be added in the ash disposal area. - Added capacity: 110,400 tons (55,200 tons x 2 piles) - Total coal yard capacity : 276,000 tons (32.5 days capacity)	- Two-pile coal yard (for ROM) will be added in the ash disposal area, as in Case 2.	- One track will be added at the time of No. 2 Unit addition for 1 additional unit of stacker/reclaimer.

Note 1: Figures in brackets [ ] show the cost in case of installation of coal blending facility.
Note 2: Cost includes installation cost an civil/architectural cost.

Table 8-9 Comparative Study of Coal Handling System for ROM Coal Firing (3/6)

		Case 1	Case 2	Case 3	Case 4
		ROM Coal Firing for No. 1 and No. 2 Units		Blended SSC with Australian Coal Firing for No. 1 Unit and ROM Coal Firing for No. 2 Unit	Blended SSC with Australian Coal Firing for No. 1 Unit and SSC Coal Firing for No. 2 Unit
Unloaders	Modification of existing facilities	- Jet water washing devices will be added for countermeasure against hopper clogging and dust. - Drainage measures will be taken. (The receiving conveyors will be made reversible, and the jet washing drain and rain water will be led to the collecting pit.)	Same as left.	Same as left.	Same as left.
	Existing facilities modification cost	$314,000	$314,000	$314,000	$314,000
	Works to be done at No. 2 Unit addition	None	None	None	None
Receiving Conveyors	Modification of existing facilities	- Since one additional stacker/reclaimer will be installed at the time of No. 2 unit construction transfer tower TT-1 will be modified accordingly to enable the operation of this stacker/reclaimer.	- Transfer tower TT-1 will be modified for switching the receiving conveyor to a new 2,400 t/h conveyor led to the expanded coal yard for Unit No. 2.	Same as left.	- Since one additional stacker/reclaimer will be installed at the time of No. 2 unit construction transfer tower TT-1 will be modified accordingly to enable the operation of this stacker/reclaimer.
	Existing facilities modification cost	$14,000	$14,000	$14,000	$14,000
	Works to be done at No. 2 Unit addition	None	None	None	None

Note 1: Figures in brackets [ ] show the cost in case of installation of coal blending facility.
Note 2: Cost includes installation cost an civil/architectural cost.

Table 8-9 Comparative Study of Coal Handling System for ROM Coal Firing (4/6)

		Case 1	Case 2	Case 3	Case 4
		ROM Coal Firing for No. 1 and No. 2 Units		Blended SSC with Australian Coal Firing for No. 1 Unit and ROM Coal Firing for No. 2 Unit	Blended SSC with Australian Coal Firing for No. 1 Unit and SSC Coal Firing for No. 2 Unit
Stacker/Reclaimer (S/R) 600 t/h capacity, enough to supply design coal to both No. 1 and No. 2 Boilers		- Since the coal handling volume increase when ROM coal of lower calorific value than the design coal is used, one unit of the existing reclaimer is short in capacity to supply ROM coal to both No. 1 and No. 2 Boilers. Consequently, it is necessary to use one reclaimer for each boiler, and there remains no spare unit, and also coal cannot be received when coal is dispensed to the boilers. Therefore, one reclaimer of the same capacity as the existing will be added at the time of No. 2 Unit construction.	- One stacker/reclaimer will be added for the expanded coal piles at the time of No. 2 Unit construction.	Same as left.	- One stacker/reclaimer will be added for the expanded coal piles at the time of No. 2 Unit construction.
	Modification of existing facilities	- For prevention of clogging of bucket wheels and for dust suppression, jet water washing device will be installed on the existing stacker/reclaimer.	Same as left.	- Water spray will be installed on the existing stacker/reclaimers for dust suppression.	Same as left.
	Existing facilities modification cost	$157,000	$157,000	$148,000	$148,000
	Works to be done at the time of No. 2 Unit construction	- One unit of stacker/reclaimer of the same capacity as the existing will be added.	- One 2,400 t/h/600 t/h stacker/reclaimer will be added. - The additional reclaimer in case of Case 1 is not necessary.	Same as left.	- One unit of stacker/reclaimer of the same capacity as the existing will be added.

Note 1: Figures in brackets [ ] show the cost in case of installation of coal blending facility.
Note 2: Cost includes installation cost an civil/architectural cost.

Table 8-9 Comparative Study of Coal Handling System for ROM Coal Firing (5/6)

		Case 1	Case 2	Case 3	Case 4
		ROM Coal Firing for No. 1 and No. 2 Units		Blended SSC with Australian Coal Firing for No. 1 Unit and ROM Coal Firing for No. 2 Unit	Blended SSC with Australian Coal Firing for No. 1 Unit and SSC Coal Firing for No. 2 Unit
Screen Crusher		- It is difficult to select a crusher that can effectively eliminate the sticking of ROM coal, and the addition of the washing device to the existing crusher is also difficult. Therefore, the particle size of the received coal will be limited within 50 mm (design particle size at the pulverizer inlet: 31.75 mm), as the condition of shipping from the coal mine, so that the load on the crusher may be limited.	Same as left.	No modification.	No modification.
	Modification of existing facilities	- For prevention of sticking of coal on the screen, water washing device will be added to the existing screens. The specifications of the existing screen will not be changed.	Same as left.	No modification.	No modification.
	Existing facilities modification cost	$86,000	$86,000	-	-
	Works to be done at No. 2 Unit addition	- One set of screen/crusher for No. 2 Unit will be added at the time of addition of No. 2 Unit. The necessity and specifications of the additional crusher should be considered carefully before the addition of No. 2 Unit.	Same as left.	Same as left.	Same as left.

Note 1: Figures in brackets [ ] show the cost in case of installation of coal blending facility.
Note 2: Cost includes installation cost an civil/architectural cost.

Table 8-9 Comparative Study of Coal Handling System for ROM Coal Firing (6/6)

		Case 1	Case 2	Case 3	Case 4
		ROM Coal Firing for No. 1 and No. 2 Units		Blended SSC with Australian Coal Firing for No. 1 Unit and ROM Coal Firing for No. 2 Unit	Blended SSC with Australian Coal Firing for No. 1 Unit and SSC Coal Firing for No. 2 Unit
Transfer Tower Chutes and Hoppers	Modification of existing facilities	- For prevention of clogging of coal at the transfer chutes and bunkers, the slopes of bunkers and chutes will be lined with Hi-Moler (Ultra-high molecular weight polyethylene), the corners of chutes will be rounded, and water washing devices will be added on all chutes. Further, to prevent clogging of coal, the shape of bunkers will be made *asymmetric*.	- For prevention of clogging of the chute in transfer tower TT-1, the slopes of the chute will be lined with Hi-Moler, the corners will be rounded, and the water washing device will be added. Other chutes and bunkers will remain as they are.	Same as left.	Same as left.
	Existing facilities modification cost	$314,000	$171,000	$171,000	$171,000
	Works to be done at No. 2 Unit addition	- Countermeasures for the chutes and hoppers added at the time of No. 2 Unit addition will be taken at the time of No. 2 Unit construction. (such as Hi-Moler lining, provision of water washing device larger size chutes, etc.)	Same as left.	Same as left.	Same as left.
Total Cost of Modification of Existing Facilities		$886,000	$743,000	$ 643,000 [$5,786,000]	$ 643,000 [$5,786,000]

Note 1: Figures in brackets [ ] show the cost in case of installation of coal blending facility.
Note 2: Cost includes installation cost an civil/architectural cost.

b. In the Case 2, by the two pile expansion of the coal yard, approximately 32 days coal storage for No. 1 and No.2 units will be possible, and there would be no problem judging from the past record of receiving of Semirara coal. But, the scope of modification of the existing facilities for use of ROM coal and the cost of it are extensive, second to Case 1, and also there are restrictions from the boiler side likewise in Case 1. Therefore, this case is not recommendable.

c. The Case 3 shows the plan that No. 1 boiler will fire the coal of current use (SSC and AC blended) and No. 2 boiler will fire exclusively ROM coal.

The scope and cost for the modification of the existing facilities as the countermeasure for use of ROM coal is comparatively small, and this case is economical, and requires no remodeling of No. 1 boiler, either. However, the case with installation of coal blending facility for accurate coal blending becomes expensive.

In case where coal yard for 2 coal piles is added for exclusive use of ROM coal, the storage capacity will cover about 26 days coal consumption. Although there is no margin in consideration of the long pause for 25 days of receiving Semirara coal, one pile out of the existing 3 piles is used for storing Australian coal or SSC as emergency coal for No. 1 and No. 2 units, and there would be no problem in the operation. Storage of 45 days volume of Australian coal or SSC for No. 1 unit is possible with the remaining 2 piles (Annual plant factor is assumed to be 70%).

d. The case 4 shows the plan that No. 1 boiler will fire the coal of current use (SSC and AC blended) and No. 2 boiler will fire SSC. The scope and cost for modification of the existing facilities as the countermeasure for use of SSC coal is small. However, the case with installation of coal blending facility for highly accurate coal blending becomes expensive.

The coal storage capacity would cover about 20 days coal consumption for No. 1 and No. 2 units, and some supplementary measures for coal storage control and operation will be required to prepare for the possibility of 25 days suspension of coal supply from SCC. If well'coordinated operation with SCC for the production of SSC is possible, this case will be realistic with a merit of the low modification cost.

8-4-3 Problems with Existing Facilities and Improvement Plans

The problems with the existing facilities and basic improvement plans are summarized in the following Table 8-10.

Table 8-10 Problems and Basic Improvement Plans

Problems	Basic Countermeasure	Facilities	Cost 10^3 (Million Yen)
Improvement of Blending Accuracy	– Coal blending hopper will be installed.	– At coal yard	5,143 (720)
	– Integrating belt scale will be added to the indicating dispensing belt scale on the reclaimer.	– Reclaimer	429 (60)
Spontaneous Combustion	– Improvement of coal stacking method – Temperature measuring device	– Coal yard	11 (1.5)
Received Coal Auto-sampler	– Auto-sampler will be repaired and utilized effectively for coal quality control.	– Auto-sampler in T-1 Tower	–
Dispensed Coal Sampler	– Existing manual sampler will be converted to auto-sampler (with timer).	– Cutter sampler	686 (96)
Dispensing Coal Scale	– Coal scale will be repaired and maintained. Sufficient spare parts will be stored.	– Coal scale on B-12	–
Modification of Receiving Conveyor TT-1	– Modification of transfer tower	– TT-1	14 (2)
Water Jet Device for Screen and Crusher	– Installation of water jet device	– Screen	9 (1.2)
Chute and Hopper	– Hi-Moler lining – Installation of water washing device	– Conveyor transfer chute and hopper	171 (24)

Problems	Basic Countermeasure	Facilities	Cost 10^3 (Million Yen)
Dust	– Installation of water sprays and dust suppressing plates on unloader hoppers	– Unloader	314 (44)
	– Installation of windbreak fence for coal yard – Water spray from stacker/ reclaimer	– Coal yard – Stacker/ reclaimer	5,343 (748) 157 (22)
	– Provision of portable vacuum cleaners for cleaning of dust and coal dropped in and around transfer towers	– Transfer towers	250 (35)
	– Improvement of sealing at trippers on the top of coal silos	– Trippers	75 (10.5)
	– Installation of hydrants and sprays	– Tripper, TT-6	93 (13)
Coal Dropping around Transfer Tower TT-6	– Dropping of coal seems to be due to overloading of belt conveyors. (Conveyor capacity is expressed in MCR, and operation should be at about 80%.) Capacity indicated on the reclaimers and dispensing conveyors will be changed.	– Dispensing conveyor and reclaimer	
Draining of Water on Yard Conveyors	– Standing water on the conveyors after rain must be removed before starting. For this, draining device will be installed on yard conveyors B-6 and B-7. – Conveyors B-1 and B-2 will be made reversible.	– Conveyors B-6 and B-7 – Conveyors B-1 and B-2	75 (10.5)
Reinforcement of Magnetic Separator	– To increase the separating ability, 2 magnetic separators will be added on the receiving line.	– Magnetic separator	143 (20)

9. Implementation Plan of Upgrading of Calaca Unit No. 1

9-1 Premises on the Study of Upgrading Plan

9-2 Measures for Increase of SSC Consumption

9-3 Upgrading Plan of Equipment

- 9-3-1 Modification of Coal Silo and Replacement of Coal Feeder
- 9-3-2 Addition of Sootblowers and Peepholes/Monitoring TV
- 9-3-3 Modification and Adjustment of Automatic Boiler Control (ABC) System
- 9-3-4 Improvement and Installation of Combustion Management Instrumentation
- 9-3-5 Installation of Coal Blending Facility
- 9-3-6 Automation of Samplers for Consumption Coal
- 9-3-7 Modification and Improvement for ROM Coal Use

9. Implementation Plan of Upgrading of Calaca Unit No. 1

9-1 Premises on the Study of Upgrading Plan

The study of upgrading plan for Calaca Unit No. 1 is based on the following premises;

(1) Since it is impossible to operate the plant at the rated output by exclusive ROM coal or SSC firing with the existing plant facilities, it is assumed that the plant operation with blended coal of SSC and Australian Coal will be continued.

(2) ROM coal will not be used for Calaca Unit No. 1 because of the difficulty in handling and low calorific value.

(3) The quality of SSC of future supply is assumed to be of high moisture and alkali content, similar to that of the coal delivered in the past. Therefore, the study of the improvement plan was made on the basis of analytical data of the past coal.

(4) Washed coal will not be considered.

As for the coal handling system, however, modification or improvement will be planned with the use of ROM coal for the future Unit No. 2 taken into consideration.

9-2 Measures for Increase of SSC Consumption

(1) The present operation of Calaca Unit No. 1 will be continued with the efforts to increase the blending ratio of the SSC. For this purpose, the plant operation will be improved as follows:

a. Under the present operating conditions, the tests to confirm the maximum allowable SSC blending ratio by use of the lower stage mills (B, C and D mills) will be carried out.

b. The characteristics of the as-received coal will be grasped immediately after the delivery of coal by means of the atomic absorption spectrophotometer.

c. In cooperation with SCC, a communication system will be established so that the coal quality and the tendency of its change may be informed

/communicated to the power plant timely.

d. The operating system allowing the maximum use of SSC will be studied. For example,

Alkali content (%)	Less than 6	6–7	More than 7	–
Blending ratio (S/A)	60/40	50/50	40/60	100/0
Output (%)	100	100	100	75

Besides, in order to make the above operation possible, the following modification works will be carried out.

a) Modification of coal silo and replacement of coal feeder
b) Addition of sootblowers and furnace peepholes/monitoring TV
c) Modification of ABC system
d) Improvement and installation of combustion management instrumentation
e) Installation of coal blending facility
f) Automation of sampler of consumption coal

(2) The coal handling system will be modified and/or improved for use of ROM coal for the future Unit No. 2.

9-3 Upgrading Plan of Equipment

9-3-1 Modification of Coal Silo and Replacement of Coal Feeder

(1) Outline of Works

The following modifications of the coal silo, will be made to prevent clogging at the coal silo and chutes:

a. Shape of the lower conical part of the coal silo will be made asymmetrical.

b. The outlet mouth of the coal silo bottom will be enlarged.

c. The inside surface of the coal silo will be lined with Hi-Moler.

d. The coal feeders will be replaced to match the modification of the coal silo.

(2) Construction Period

Coal silos will be modified and coal feeders will be replaced, one by one during the overhaul period or with the unit in operation.

(3) Effects

a. To decrease coal clogging in the rainy season when SSC is exclusively fired.

b. To prevent output reduction caused by clogging.

(4) Planning Drawing of Modification

Refer to Fig. 9-1.

9-3-2 Addition of Sootblowers and Peepholes/Monitoring TV

(1) Outline of Works

a. A long retractable type sootblower will be added at each side of the lower part of the plate type superheater.

b. The existing long retractable sootblowers of one set each for upper part of primary superheater, left and right side, shall be relocated and the same type sootblowers shall be additionally installed.

c. Two peepholes will be made on each side of the furnace walls.

d. Two peepholes or one monitoring TV will be provided above the primary superheater.

(2) Construction Period

Construction works will be done in the overhaul period.

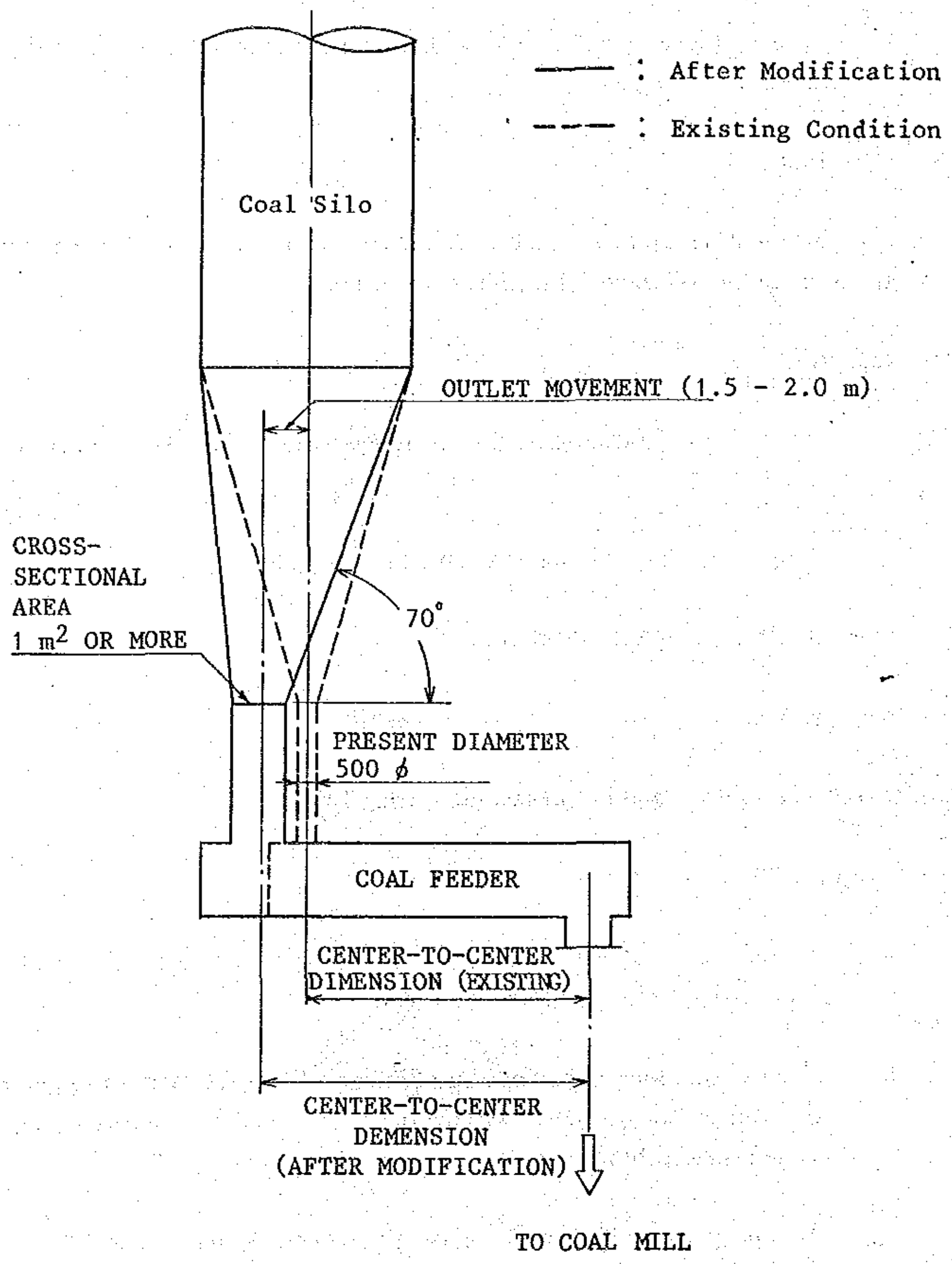


Fig. 9-1 Modification of Silo and Replacement of Coal Feeder

(3) Effects

a. Slag will be removed at the beginning by monitoring the growth of slagging through peepholes/TV, since probability of slagging and fouling will increase with the increase of blending ratio of SSC.

b. In order to prevent growth of slagging, even a reduction of the output of the unit would be necessary.

c. If sootblowers are used too frequently, there would result the problems of wear of tubes and thermal stress. Therefore, the sootblowing should be done at proper intervals by monitoring the furance properly.

(4) Planning Drawing of Modification

Refer to Fig. 9-2.

9-3-3 Modification and Adjustment of Automatic Boiler Control (ABC) System

(1) Outline of Works

a. Existing conditions will be investigated and readjusted.

b. Drum level control will be modified to one loop control system.

c. Coordination control device will be added between the load management control system and the automatic boiler control devices.

(2) Construction Period

Investigation and adjustment will be carried out in 3 months during unit operation. Installation of new equipment will be done during the overhaul period.

(3) Effects

a. On-governor operation will become possible and 3%/min. load change will be attainable under stable condition.

b. Steam temperature and pressure will be stable, which will make equipment life longer and improve the performance of the unit.

c. Contribution will be made to the stability of system frequency.

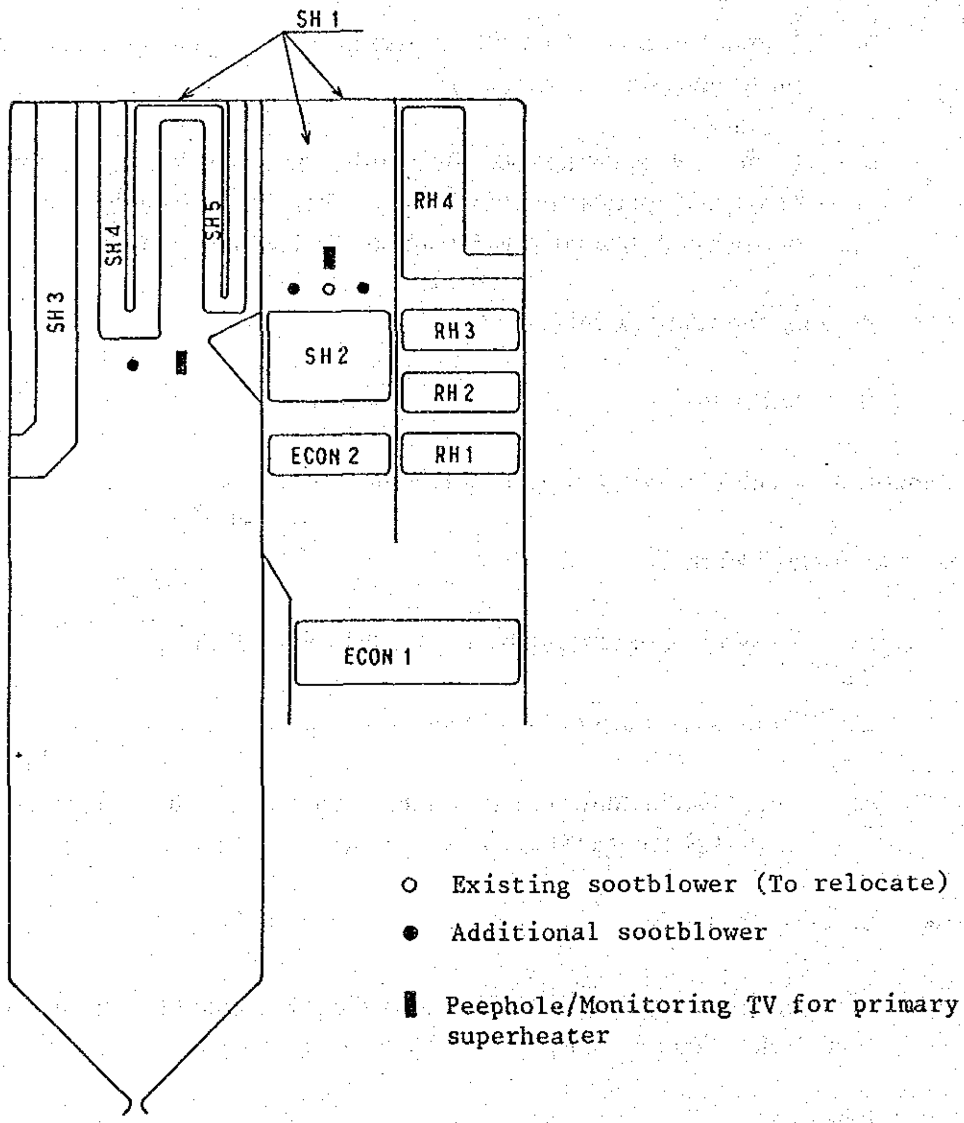


Fig. 9-2 Additional Sootblowers and Peepholes

9-3-4 Improvement and Installation of Combustion Management Instrumentation

(1) Outline of Works

a. The flame monitoring system has some problems in the logic, which will be improved to avoid malfunction.

b. After the repair of flue gas O_2 meters, imbalance of flue gas flow will be corrected. For this purpose, measurement of the fuel-air velocity in fuel pipes and adjustment of burner air registers will be required.

c. Position indicators of burner air registers and actual positions will be collated and the remote indicators on the central control panel will be repaired.

d. Classifier vanes of the coal mill will be repaired so that they may be adjustable according to the fineness of pulverized coal.

e. Since there are some discrepancy among coal scales (indicators on control board, controllers, and data logger), they will be calibrated and collated.

f. Some additional instruments, such as dual monitor in the flue gas, level gauge in the coal silo, coal clogging detector, etc. will be installed/replaced.

(2) Construction Period

Works will be done during the overhaul period.

(3) Effects

a. It is expected that erratic unit trips will be prevented by improvement of the flame detector system.

b. After proper adjustment of the instruments, operation will be done as designed which will result in plant efficiency increase.

c. Ash clogging troubles caused by incomplete combustion will be prevented by appropriate supply of combustion air.

d. Proper combustion will be maintained by supply of pulverized coal with appropriate fineness.

e. Adequate monitoring of operation will become possible, so that good combustion can be attained.

9-3-5 Installation of Coal Belnding Facility

(1) Outline of Works

a. Coal blending hoppers (110 tons x 2 sets) will be installed.

b. Coal will be transferred to each coal blending hopper by the existing conveyors B-6 and B-7 respectively, and accurate coal blending will be obtained.

c. Belt conveyors and coal scales necessary for the said works will be installed.

(2) Construction Period

The coal blending facility will be installed during unit operation, and the conveyors will be connected during the unit overhaul.

(3) Effects

Higher accuracy in coal blending will be obtained, and blending ratio as high as 10 : 1 will be possible. (By the relcaimer blending method, blending accuracy is low, and this high blending ratio will not be possible.)

9-3-6 Automation of Samplers for Consumption Coal

(1) Outline of Works

The coal sampler for consumption coal installed at TT-6 are of remote manual control type, and it is not used at present because of difficulty in operation. This sampler, therefore, will be automated for precise management of coal consumption. Refer to Fig. 9-3.

a. Sampling devices will be automated.

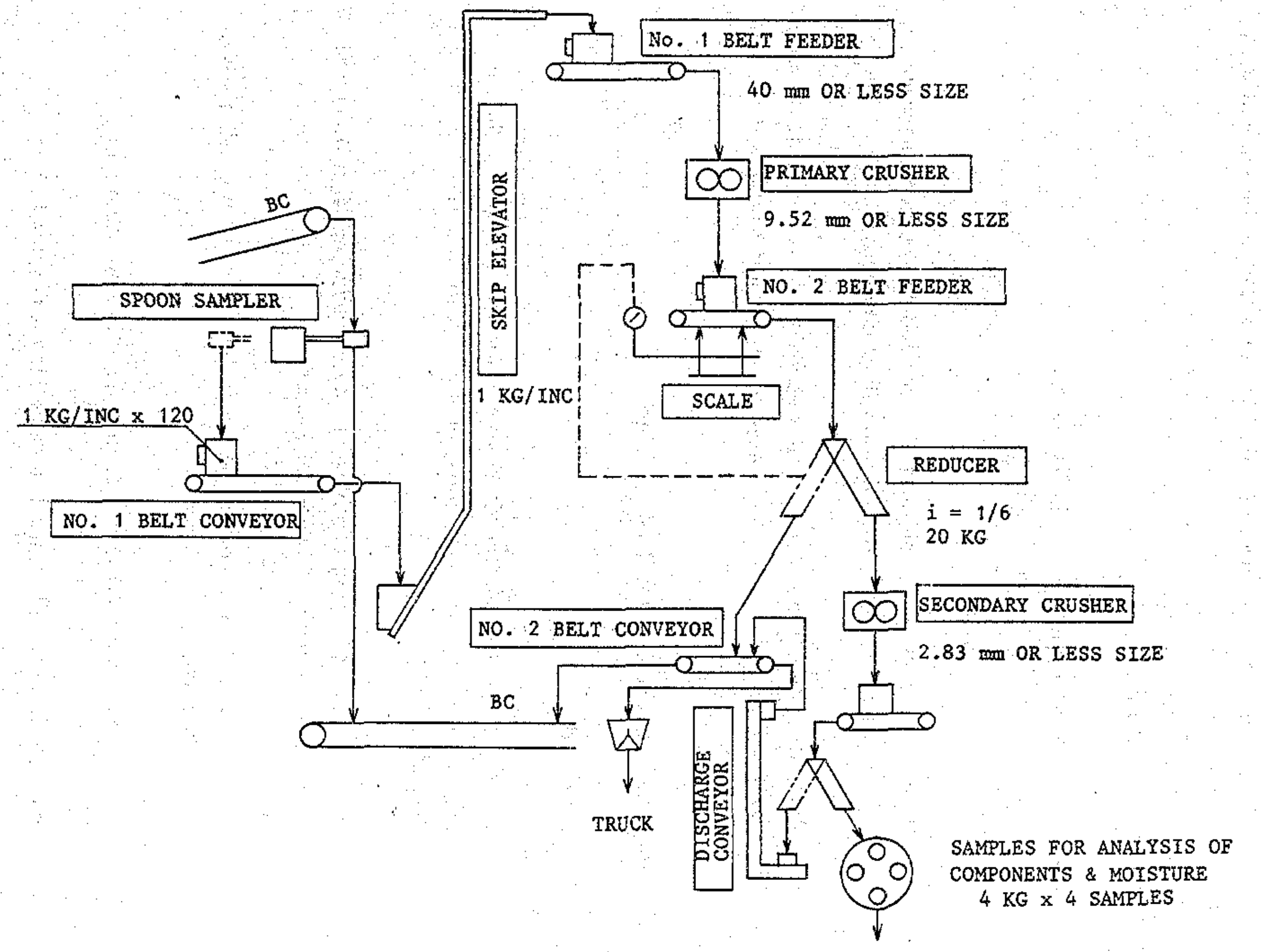


Fig. 9-3 Flow Diagram of Sampling and Reducing Device

b. Primary and Secondary coal crushers and sample reducing devices will be installed in order that primary reduced coal samples will be taken out.

c. Conveyors and other necessary devices for sampling system will be installed.

(2) Construction Period

Works will be done during the overhaul period.

(3) Effects

a. At present, consumed coal is not analyzed and precise stock management is not carried out, but this condition will be improved.

b. Properties of consumed coal (calorific value, moisture content, alkali content) will be grasped and proper coal blending ratio will be established.

9-3-7 Modification and Improvement for ROM Coal Use

(1) Outline of Works

a. In the case that ROM coal will be used for Calaca Unit No. 2, the following improvement will be required. (The case where coal stock yard will be expanded.)

a) Change of shape of unloader chutes including High-Moler lining and installation of water jet washer.

b) Change of hoppers and chutes in the transfer tower, similarly to the above.

c) Modification for reversible running of B-1, B-2 conveyors.

b. Windbreak fence will be installed alongside the coal yard.

c. The following countermeasures for dust prevention will be taken.

a) Sprinkler facilities and dust preventive plates will be installed on the unloader. (Water washing facilities will be installed for ROM coal firing.)

b) Sprinkler facilities will be installed on the stackers and reclaimers.

c) Vacuum cleaning system will be provided to keep good condition.

d) Seals for trippers in the bunker room will be installed.

e) Sprinklers for coalyard and fire fighting facilities will be reinforced.

d. Water draining devices for B-6, B-7 conveyors will be installed.

e. Magnet separator will be added.

f. Auto-sampler and coal scales for delivered coal will be maintained in good condition.

g. Tools will be procured to cope any troubles.

(2) Construction Period

Twelve (12) months will be required. Works which need a long shutdown of the coal handling system (consumption coal handling system) will be done during the overhaul period of the unit.

(3) Effects

a. In the case that ROM coal will be used for Unit No. 2, related equipment will have to be prepared in good condition.

b. The coal handling system is gradually deteriorated because of difficulties of maintenance works due to dust and spilled coal, and thus, there will be problems for future plant operation. Plant environmental conditions and equipment and tools, therefore, will be kept in good condition.

10. Economic and Financial Evaluation

The Calaca Unit No. 1 Upgrading Plan is aimed at maximum utilization of the indigenous energy resources by reduction in foreign coal consumption. In view of the economy in the Philippines (Economic Evaluation), the implementation of this project will bring about such economic merit as saving of the important foreign exchange spent for purchase of the coal from abroad.

On the other hand, if this upgrading plan is viewed from financial aspect of NAPOCOR, operating the sale of electricity generated by Calaca Power Plant, the implementation of the plan will increase the generating cost since the plan is intended to increase the consumption of the local coal, and the unit cost per calorific value is higher than that of the imported coal.

So, this upgrading plan is a special project involving two contradictory aspects in terms of economy. If the upgrading plan should be expected with the maximum effect of economy, or sharp increase in the local coal blend ratio, the consequence would be a steep rise of the generating cost, sound operation at which of the power plant would hardly be managed.

In view of the above aspect the economic internal rate of return (EIRR) of each case of the upgrading plan was calculated with the "Benefit" of foreign exchange saving derived from the improvement of the blending ratio and plant reliablility/performance as a preliminary economic evaluation. With reference to the results, the technically feasible and practical upgrading plans were put together as an upgrading project.

With respect to the upgrading project, the economic and financial feasibility were evaluated by the internal rate of return method. However, because the upgrading project will give an adverse effect to the financial feasibility, the financial feasibility was tested if the investment to and raise of generating cost by the upgrading project could be absorbed in the cash flow of the original project. Further, financial effects between the With and Without upgrading project were compared.

10-1 Preliminary Economic Evaluation

10-1-1 Evaluation Method

The economic "benefit" of each upgrading plan is foreign exchange saving equivalent to the curtailment of imported fuel (oil and coal) after implementation of each plan. And the "cost" is expenses for procurement, supply, transportation and installation of equipment and materials as well as fuel accompanied by the implementation of each upgrading plan.

And an economic internal rate of return, or a discount rate at which the cost and benefit is equalized approximately, was calculated.

10-1-2 Assumptions

The power plant was being operated with the blending ratio of 50 : 50 (weight base) when this upgrading plan was formulated. The blending ratio was considered as the base. And other plant operating conditions and fuels were assumed as follows:

(1) Calaca Power Plant

Output:	300 MW
Capacity factor:	70%
Efficiency:	35.3%

(2) Alternative Oil Power Plant (Sucat No. 4)

Output:	300 MW
Efficiency:	29.4%

(3) Fuel

	Calorific Value (kcal/kg)	Unit Cost (₱/t)
Australian coal	6,090	648
Semirara coal (SSC)	4,390	750
Oil	10,000	2,642 (20 $/bbl)

(4) Implementation

Each upgrading work was assumed to be carried out in 1988 and effective from 1989 to 2009. However, the construction period of cases A.4 (New construction of a boiler) and A.5 (Replacement of a boiler) was estimated at 40 months.

(5) Exchange Rate

US$1 = ₱21 = ¥140

10-1-3 Cost and Benefit

(1) Case A.1

Continuation of present operation with improvement of operation and maintenance.

a. Cost

None.

b. Benefit

The domestic coal blending ratio can be improved by 10%, or annual saving of Australian coal amounting to about 44,400 tons which produces annual benefit of about ₱28.8 million, or ¥190 million, while alkali content of the coal is favorable during 60% of a year.

c. EIRR

None.

(2) Case A.2

Derated output operation (225 MW) for improvement of SSC blending ratio.

a. Cost

- ₱95 million or ¥630 million for modification of coal silo and coal feeder.
- ₱355 million, or ¥2,600 million annually for fuel oil expense if 75 MW output is supplemented by the alternative oil thermal (Case A.2.0).
- No cost in terms of foreign exchange if the output is not necessary in demand or supplemented by the power plant with domestic energy such as hydro and geothermal (Case A.2.1).

b. Benefit

By derated operation of 225 MW, the exclusive SSC firing will be possible and that will produce the Australian coal saving of 427,000 tons annually equivalent to ₱277 million, or ¥1,848 million.

c. EIRR

A.2.0:	Total loss
A.2.1:	293.26%

(3) Case A.3

Beldning ratio improvement by modification of boiler.

a. Cost

- ₱237 million, or ¥1,580 million for modification of the boiler.
- ₱710 million, or ¥4,700 million if the oil-thermal plant is operated during 6 months of shutdown for boiler modification (Case A.3.0).
- No cost if the plant using the domestic energy will be operated (Case A.3.1).

b. Benefit

The SSC blending ratio improvement by 5% will curtail 36,400 tons of the Australian coal annually which saves annual cost of ₱24 million, or ¥160 million.

c. EIRR

A.3.0:	-5.27%
A.3.1:	7.97%

(4) Case A.4

New construction of boiler for exclusive ROM/SSC firing.

a. Cost

- New construction of a boiler is estimated at ₱2,322 million or ¥15,480 million.

- New construction of boiler will need 6 months of the plant shut-down, during which period, an oil thermal plant will take the place of Calaca. The fuel will cost about ₱710 million, or ¥4,730 million (Case A.4.0).

- No cost if the operation of Calaca is not required or other plant with domestic energy takes place (Case A.4.1).

b. Benefit

Exclusive ROM/SSC firing will save about 427,600 tons of Australian coal annually amounting to ₱277 million, or ¥1,850 million.

c. EIRR

A.4.0:	5.27%
A.4.1:	8.04%

(5) Case A.5

Replacement of the existing boiler with new one for exclusive ROM/SSC firing.

a. Cost

- The boiler replacement is estimated at ₱2,392 million, or ¥15,950 million.

- ₱4,739 million, or ¥31,600 million for fuel consumed by oil thermal during 40 months of shutdown (Case A.5.0).

- No cost in terms of foreign currency if the other plant with domestic energy takes the Calaca's place for said period (Case A.5.1).

b. Benefit

Exclusive ROM/SSC firing will save about 427,600 tons of Australian coal annually amounting to ₱277 million, or ¥1,850 million.

c. EIRR

A.5.0:	-2.95%
A.5.1:	7.69%

(6) Case B.1

Modification of coal silo and coal feeder.

a. Cost

The modification cost is estimated at ₱94 million, or ¥630 million.

b. Benefit

In the rainy season, the plant output is assumed to reduce by 50 MW for about two hours, 2 times a week in a rainy season due to coal handling troubles. Since the modification is expected to prevent the troubles, about 1,521 kl used by the oil thermal during the period can be saved. And a unit trip per year (assumed to be 10 hours) by coal clogging at coal silo can be prevented. That will save 878 kl of oil consumed by the alterantive oil thermal. The total fuel save amounts to ₱6 million, or ¥42 million annually.

c. EIRR

3.35%.

(7) Case B.2

Additional installation of 4 sootblowers.

a. Cost

The installation cost is estimated at ₱10.5 million, or ¥70 million.

b. Benefit

The fouling troubles causing 2 unit trips per year (total of 70 hours) are assumed to be prevented. This results in fuel saving of 6,143 kl by other oil thermal which amounts to ₱16 million, or ¥107 million.

c. EIRR

154.59%.

(8) Case B.3

Modification of ABC system.

a. Cost

The modification cost is estimated at ₱10.5 million, or ¥70 million.

b. Benefit

The ABC system hunting was the causes of low pressure and temperature operation of the plant. Prevention of the hunting will recover 0.1% of the plant efficiency which is equivalent to 1,208 tons of Australian coal saving. And also, the unit trips (2 times a year for total of 10 hours) are assumed to be prevented. That saves about 878 kl of fuel oil consumed by the other power plant. The total benefit by this improvement amounts to ₱3 million, or ¥20 million annually.

c. EIRR

29.42%.

(9) Case B.4

New installation of blending facility.

a. Cost

The new construction will cost ₱108 million, or ¥720 million.

b. Benefit

The accurate blending will increase the SSC coal blending ratio by 5% equivalent to Australian coal saving of 36,000 tons costing about ₱24 million, or ¥160 million annually.

c. EIRR

21.49%.

(10) Case B.5

New installation of a coal scale with reclaimer.

a. Cost

The new installation is estimated at ₱9 million, or ¥60 million.

b. Benefit

The accurate coal scaling will improve the SSC coal blending ratio by 2.5%. About 18,000 tons of Australian coal can be saved annually. The annual foreign exchange saving will be about ₱12 million, or ¥80 million.

c. EIRR

130.03%.

(11) Case B.6

Installation of a new dryer.

a. Cost

The construction cost is estimated at ₱142 million, or ¥950 million.

b. Benefit

The exclusive SSC firing can be done owing to the dryer operation when the alkali content becomes low (to be assumed 40% period of a year).

The blending ratio in the remaining period of the year is 50 : 50. The total fuel saving is 171,059 tons equivalent to ₱94 million, or ¥630 million annually.

c. EIRR

65.97%.

(12) Case C.1

Fuel additives and construction of a new dryer.

a. Cost

- Cosntruction of new dryer costs ₱142 million, or ¥950 million.
- Annual cost of the fuel additives is estimated at ₱39 million, or ¥260 million.
- Annual cost of fuel for dryer operation (15,940 kl/year) is ₱42 million, or ¥280 million.

b. Benefit

The blending ratio of 80 : 20 may be possible when alkali content is high (about 60% period of a year) – (144,003 tons of fuel saving). And the exclusive SSC firing is possible at the low alkali content period (40% period of a year) – (171,059 tons of fuel saving). Further the dryer operation improves the plant efficiency by 0.35%. The total fuel saving will be 314,600 tons equivalent to the foreign exchange of about ₱204 million, or ¥1,359 million.

c. EIRR

86.41%.

10-1-4 Summary of Preliminary Economic Evaluation

The study results of the above are summarized in Table 10-1 below. According to the results, the upgrading plans of Case A's except A.1 will need a larger amount of investment and increase the SSC blending ratio correspondingly. Since the scale of works is generally extensive, however, the construction works will need the plant shutdown for a certain period, or the other plan (A.2.0) will require derated operation. In consideration of the tight power demand and supply conditions in the Luzon at present, application of these plans is not practicable and the economic effect is less than that of Case B's and C.

Regarding the Case C's, the fuel additives are effective to raise the blending ratio of the domestic coal in return of large amount of annual cost for the additives if possible. In view of the generating cost as one of the important factors of financial evaluation, the Case C which will raise the consumption of the dear domestic coal with the large annual expense, is feared to worsen the financial condition of the power plant.

Therefore, it is judged from the economic view point that the Case A.1 and some of the B's are desirable to be formulated as an upgrading project in the extent that the project implementation would not result in the sharp rise of the generating cost, or financial difficulties of the power plant operation by NAPOCOR.

For reference, the sensitivity of the generating cost to the variable blending ratio between Australian coal and SSC is shown on Fig. 10-1.

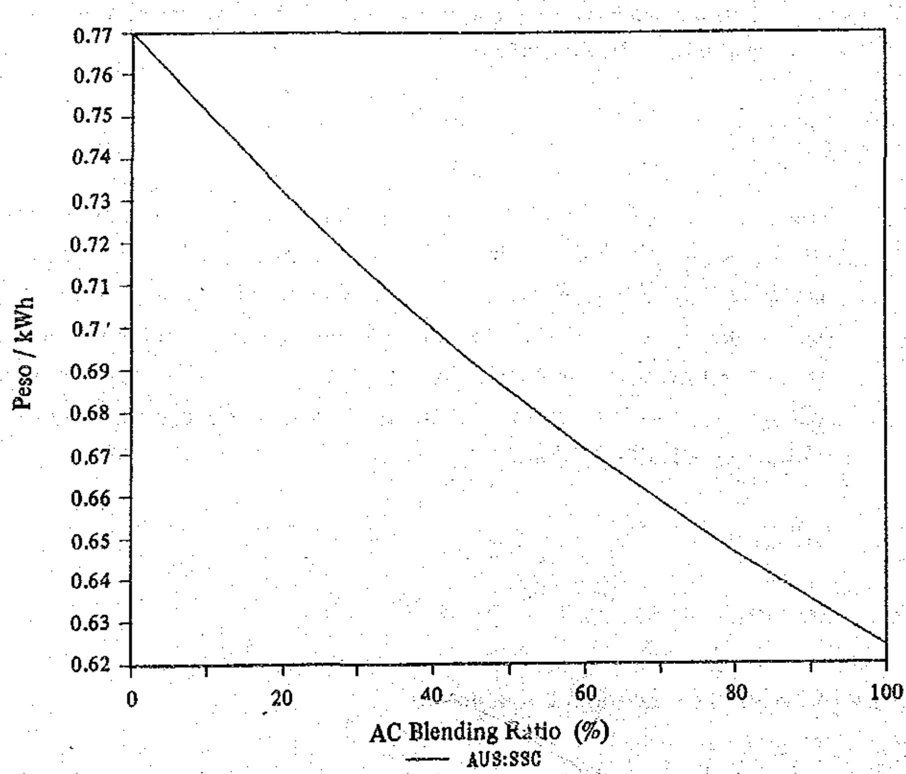


Fig. 10-1 Sensitivity of Generating Cost

Table 10-1 Results of Preliminary Economic Evaluation

Case	Upgrading Plan	Cost (M₱)	Benefit (M₱/yr.)	EIRR (%)
A.1	Continuation of present operation with improvement of operation and maintenance	0	28.8	–
A.2.0	Derated output (225 MW) operation (with operation of oil thermal)	95	-78	x
A.2.1	Derated output (225 MW) operation (Without operation of oil thermal)	95	277	293.26
A.3.0	Boiler modification (With operation of oil thermal)	946	24	-5.27
A.3.1	Boiler modification (Without operation of oil thermal)	237	24	7.97
A.4.0	Construction of a new boiler for exclusive ROM/SSC firing (With operation of oil thermal)	3,033	277	5.27
A.4.1	Construction of a new boiler for exclusive ROM/SSC firing (Without operation of oil thermal)	2,322	277	8.04
A.5.0	Replacement with a new boiler for exclusive ROM/SSC firing (With operation of oil thermal)	7,132	277	-2.95
A.5.1	Replacement with a new boiler for exclusive ROM/SSC firing (Without operation of oil thermal)	2,392	277	7.69
B.1	Modification of silo and coal feeder	95	6	3.35
B.2	Addition of 4 sootblowers	11	16	154.59
B.3	Modification of ABC system	11	3	29.42
B.4	Installation of blending facility	108	24	21.49
B.5	Installation of a coal scale on reclaimer	9	12	130.03
B.6	Installation of a new dryer	142	94	65.97
C.7	Fuel additives and installation of a new dryer	142 + 81/yr.	123	86.41

10-2 Economic Evaluation of Upgrading Project

10-2-1 Evaluation Method

With respect to the upgrading project formulated as a result of technical and economic evaluations, the economic evaluation was made by the internal rate of return method. In line with the purpose of the project, the "benefit" is the foreign exchange saving equivalent to the cost for purchase of the imported coal derived from improvement of the blending ratio for increase of domestic coal consumption. And the expenses for the upgrading works were appropriated to the "cost". Based on the overall schedule of the project, the economic internal rate of return will be calculated in the similar manner of the preliminary economic evaluation. And the obtained EIRR was compared with the discount rate of 15% set by the National Economic and Development Authority (NEDA) of the Philippines.

10-2-2 Cost and Benefit Flow

(1) Cost

As a result of preliminary economic and technical evaluations, the following items of works were selected as an upgrading project. And the cost of the upgrading works are broken down as follows.

No.	Item	Cost	
		(Million Peso)	(Thousand Dollar)
A.1	Continuation of present operation with improvement of operation and maintenance	0	0
B.1	Modification of coal silo and coal feeder	94.5	(4,500)
B.2	Addition of 4 sootblowers	10.5	(500)
B.3	Modification of ABC system	10.5	(500)
B.4	Installation of a new blending facility	108	(5,143)
D.1	Other improvement works	164.5	(7,830)
	(Improvement of instruments)	(9)	
	(Automation of consumption coal sampler)	(14.4)	
	(Improvement of coal handling equipment)	(141.1)	
	Total (incl. supply, transportation and installation)	388	(18,479)
	Consultant fee	12	(571)
	Total cost	400	(19,050)
	Contingency	38	(1,850)
	Total project cost	438	(20,900)

The cost of the economic evaluation is the total cost which does not include the contingency.

(2) Construction Schedule

The upgrading works will be carried out during the scheduled shutdown and periodical overhaul as much as possible. The actual works are expected to start at the beginning of 1990 and completed within the year. Therefore, this study assumed that the project cost would be disbursed in 1990.

(3) Benefit

The upgrading plans are categorized into two kinds of project namely increase of SSC blending ratio and improvement of reliability/performance.

The economic benefit by implementation of the upgrading project is summarized as follows:

No.	Upgrading Plans	Fuel Save	
Plan for increase of SSC blending ratio			
A.1	Improvement of SSC blending ratio by 10% (60% period of a year)	Coal:	44,435 t
B.4	Improvement of SSC blending ratio by 5% (ditto)	Coal:	23,354 t
	Sub-total	Coal:	67,789 t
Plan for improvement of reliability/performance			
B.1	Prevention of 50 MW load down two times a week in a rainy season	Oil:	1,521 kl
	Prevention of a unit trip per year	Oil:	878 kl
B.2	Prevention of two unit trips per year	Oil:	6,143 kl
B.3	Improvement of efficiency by 0.1%	Coal:	889 t
	Prevention of two unit trips per year	Oil:	878 kl
D.1	Improvement of reliability and controllability	—	
	Sub-total	Coal: Oil:	889 t 9,420 kl
	Total	Imported Coal: Imported oil:	68,678 t 9,420 kl

With the economic merits tabulated above, the implementation of the upgrading project will save the foreign exchange amounting to ₱69 million, or ¥463 million annually, and through 19 years from 1991 to 2009, the foreign exchange saving will be accumulated to ₱1,318 million, ¥8,790 million.

10-2-3 Result of Economic Evaluation

Based on the above mentioned conditions, the EIRR was calculated in 2 cases: Case (I); improvement of SSC blending ratio by *9% (15% x 60%), and Case (II); improvement of SSC blending ratio by 15%.

	EIRR (%)
Case (I) (Base) :	16.37
Case (II) :	24.27

The obtained EIRR of each case exceeds the hurdle rate of 15% set by NEDA. The upgrading project is economically justified to be profitable to the Philippines.

The merit calculation table of Case (I) is shown on Table 10-2 and the EIRR calculation is shown on Table 10-3.

Furhter, the EIRR's representing that obtained from the improvement of blending ratio and that from the improvement of reliability are separately calculated for Case (I) as follows.

And for a reference purpose, Case (I'), the cost of which is the one with deducted cost of the work item D-1 providing little financial merit, is also calculated.

Case	Blending Ratio (EIRR %)	Reliability (EIRR %)	Total (EIRR %)
(I)	22.17	10.33	16.37
(I')	41.15	20.97	30.86

Note: The cost of Case (I') is the sum of those of A.1 and B.4 for blending ratio increase and those of B.1, B.2 and B.3 for reliability improvement. As for the cost of Case (I), a half of D.1 cost each is additionally appropriated for blending ratio and reliability calculations, respectively to those of Case (I').

*; Because of the improvement of coal blending accuracy, 15% increase in SSC blending ratio will be possible however, since the past SSC delivery record shows that the coal with alkali content of 6% or less, which can only permit that increase in SSC blending ratio of 15%, account for 60% of annual delivery. Therefore, annual average increase in SSC blending ratio will actually be 9% (15% x 60%).
Case II is calculated on the assumption that the SSC with the alkali content of 6% or less will be delivered throughout the year.

Table 10-2 Merit Calculation for Economic Evaluation of Calaca No. 1 Upgrading Project

DESPCRIPTION	UNIT	VALUE			Case:	Upgrading Project Improvement of blending ratio by 15%			Case No. : (1)			
Project cost total (1987 price)	KPeso		400,029	2,667 Mill. Yen								
Start of construction	Year		1988									
Upgrading plan case no.		A.1	B.1.a	B.1.b	B.2	B.3.a.	B.3.b.	B.4	Others	Total	Consul. Fee	Project Cost
Cost of upgrading plans	K-Peso	0	94,495		10,499	10,499		107,995	164,542	388,030	11,999	400,029
	M-Yen	0	630		70	70		720	1,097	2,587	80	2,667
MERIT CALCULATIONS												
Capacity	MW	300	300	50	300		300	300				
Efficiency (Calaca)	%	35.30%						35.30%				
Efficiency (Alternative oil)	%		29.40%	29.40%	29.40%		29.40%					
Efficiency improvement	%					0.10%						
Capacity factor	%	70.00%						70.00%				
Original blending ratio	%	50.00%						40.00%				
AUS blending ratio	%	40.00%						35.00%				
AUS cal value	Kcal/Kg	6090						6090				
SSC Cal. value	Kcal/Kg	4390						4390				
Oil cal. value	Kcal/Kg		10000	10000	10000		10000					
Operating hour rate/year	%/year	60.00%	0.11%	1.19%	0.80%		0.11%	60.00%				
Coal fuel save/year	T/year	44,435				889		23,354	0	68,678 T/year		
Unit cost (C&F)	P/ton	648				648		648				
Oil fuel save/year	T/year		878	1,521	6,143		878		0	9,420 T/year		
Unit Cost (US20$/bbl)	P/ton		2,642	2,642	2,642		2,642					
Fuel save (Coal)	K-peso	28,794	0	0	0	576	0	15,133	0	44,503 K-peso		
Fuel save (Oil)	K-peso	0	2,320	4,018	16,230	0	2,320	0	0	24,888 K-peso		
Exchange rate	Peso/US$	21							Total	69,391 K-peso		
	Peso/Yen	6.667								463 M-yen		
	Yen/US$	140										

Table 10-3 Economic Evaluation Case (I)

	Table 10-3 Economic Evaluation: Case (I)			Improvement of Blending Ratio			Improvement of Reliability		
			IRR= 16.37%			IRR= 22.17%			IRR= 10.33%
Year	Project Cost	Forex Save by Improvement of Blending Ratio	(Unit: 000 peso) Balance	Project Cost (Blend. Increase)	Forex Save by Improvement of Blending Ratio	(Unit: 000 peso) Balance	Project Cost (RealiabilityImprovement)	Forex Save by Improvement of Reliability)	(Unit: 000 peso) Balance
1987	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0
1990	400,029	0	(400,029)	196,266	0	(196,266)	203,764	0	(203,764)
1991	0	69,391	69,391	0	44,503	44,503	0	24,888	24,888
1992	0	69,391	69,391	0	44,503	44,503	0	24,888	24,888
1993	0	69,391	69,391	0	44,503	44,503	0	24,888	24,888
1994	0	69,391	69,391	0	44,503	44,503	0	24,888	24,888
1995	0	69,391	69,391	0	44,503	44,503	0	24,888	24,888
1996	0	69,391	69,391	0	44,503	44,503	0	24,888	24,888
1997	0	69,391	69,391	0	44,503	44,503	0	24,888	24,888
1998	0	69,391	69,391	0	44,503	44,503	0	24,888	24,888
1999	0	69,391	69,391	0	44,503	44,503	0	24,888	24,888
2000	0	69,391	69,391	0	44,503	44,503	0	24,888	24,888
2001	0	69,391	69,391	0	44,503	44,503	0	24,888	24,888
2002	0	69,391	69,391	0	44,503	44,503	0	24,888	24,888
2003	0	69,391	69,391	0	44,503	44,503	0	24,888	24,888
2004	0	69,391	69,391	0	44,503	44,503	0	24,888	24,888
2005	0	69,391	69,391	0	44,503	44,503	0	24,888	24,888
2006	0	69,391	69,391	0	44,503	44,503	0	24,888	24,888
2007	0	69,391	69,391	0	44,503	44,503	0	24,888	24,888
2008	0	69,391	69,391	0	44,503	44,503	0	24,888	24,888
2009	0	69,391	69,391	0	44,503	44,503	0	24,888	24,888
2010	0	0	0	0	0	0	0	0	0
2011	0	0	0	0	0	0	0	0	0
2012	0	0	0	0	0	0	0	0	0
Total	400,029	1,318,429	918,400	196,266	845,557	649,292	203,764	472,872	269,109

10-3 Financial Evaluation

10-3-1 Method of Financial Evaluation

The financial soundness of the Calaca thermal power plant after implementation of the upgrading project through the plant life was evaluated.

As aforementioned, the purpose of the project is aimed at minimizing the use of the imported coal, and therefore the project implementation will bring about raise of the generating cost since the plant will come to use a larger quantity of domestic coal cost per unit calorific value of which is higher than that of the imported coal. It is said, therefore, that the scheme is not beneficial to the power plant nor the owner, NAPOCOR. However, the public utilities consuming the energy resources must be operated in compliance with the energy policy established by the government, even though adoption of the policy is against the profitability. But the implementation of the project should not result in ultimate financial deficit for the plant operation.

Thus, the cost of this project is presumed as additional capital to be invested to the original project, and the financial viability of this project was tested in the cash flow of the original project with this additional investment for the economic life of the power plant.

The "cost" is sum of the cost for the construction of the plant, investment to be made under this upgrading project, and operation and maintenance including fuel. And the revenue by selling of electricity generated by the plant was appropriated as the "benefit". And the financial internal rate of return (FIRR) by the similar method taken in the economic evaluation was calcualted. If the FIRR of the Calaca Power Plant incorporating the upgrading project scheme is greater than the opportunity cost of capital applied for the original project, the implementation of the upgrading project is accepted.

10-3-2 Cost and Benefit

(1) Outgoing Cashflow

a. Original project cost

According to the Completion Report of Calaca No. 1 unit prepared by Kennedy and Donkin, British consultant, the construction of the plant costed about ₱2,000 million.

But the above cost does not show the current value of the plant because the exchange rate of the currencies spent for the original project greatly changed since then. And NAPOCOR indeed made revaluation of the asset after upheaval in the country. Thus, the revalued cost of the power plant was estimated from the depreciation in 1986 amounting to ₱426,884 x 10^3, service life of 25 years and sum of the year digit method of depreciation as follows:

$$₱426,884 \times 10^3 \times \frac{335}{23} = ₱6,032,056 \times 10^3$$

b. Upgrading cost

The total project cost including consultant fee and contingency is estimated at ₱438 million (¥2,926 million). According to the overall schedule, the works will be carried out in 1990. So, all the cost is assumed to be disbursed in 1990.

c. Operating expenses

For a period from October 1984 to the end of 1986, the actual operating record with some revision was applied. For 4 years from 1987 to 1990, the blending ratio was assumed to be 50 : 50. And after upgrading works in 1990 up to the retirement of September 2009, the blending ratio of 59 : 41 was assumed to continue. (For a period of 60% of a year, the plant will be operated with the fuel blending ratio of 65 : 35 and for the remaining period the blending ratio will be 50 : 50.)

The fuel costs used are:

Australian coal:	675 ₱/ton	(incl. Halg. Cost)
SSC:	750 ₱/ton	

And other operation and maintenance cost was assumed to be 0.03432 ₱/kWh according to the 1986 record of NAPOCOR.

(2) Benefit

In addition to the 0.1% of the efficiency improvement and change of blending ratio as discussed in the economic evaluation and above, the upgrading plan is assumed to contributable to the increase of capacity factor by about 2% (sum of the prevention of unit trips and others) by improvement of reliability, decrease of troubles and maintenance shutdown. Thus, after upgrading works, capacity factor increase by 2% equivalent to about 44 GWh of salable energy was appropriated in the cash flow.

The benefit of the power plant will be revenue of electricity sales after station service loss, transmission loss and general account not attributable to the plant's revenue for 25 years from commissioning to retirement.

The power rate of 1.0552 ₱/kWh used in the financial calculation is an average of 1986 Luzon Grid.

Plant efficiency:	35.40%	(0.1% up)
Capacity factor:	70%	(2% up)
Station loss:	5.53%	(Average of 1985, 1986 and a half of 1987)
Transmission loss:	8.53%	(From 1986 NAPOCOR Annual Report)
General account:	2.5%	(From 1986 NAPOCOR Annual Report)

(3) Repayment

a. Repayment of original project cost

For construction of the original project including transmission lines, NAPOCOR procured 6 loans amounting to about US$56 million and ¥43.7 billion from 5 different lending institutes. For preparation of the repayment schedule of the original project, were used as follows:

Interest:	8.5% p.a. (Incl. commitment fee)
Life of loan:	15.5 years
Grace period:	3.5 years
Repayment period:	12 years
Terms of payment:	Semi-annual

b. Repayment of upgrading project cost

In the conservative stand point of view, terms and conditions of the loan used for the original project were used for the upgrading project, too.

(4) Other Assumptions

a. The depreciation was made by a sum-of-the-year digit method without residual value which NAPOCOR has adopted since 1984.

b. Interests of both original and upgrading projects during the grace period were capitalized.

c. Other conditions like exchange rate were the same as the ones used in the economic evaluation.

10-3-3 Result of Financial Evaluation

(1) Financial Internal Rate of Return (FIRR)

The FIRR calculated with the conditions above recorded 13.67%. Since the obtained FIRR is well clear the opportunity cost of capital at 8.5%, if this upgrading project is implemented, the cost for and raise of generating cost by the upgrading project will be well absorbed in the cash flow of the original project and financial soundness of Calaca power plant operation is justified. The calculation process of the FIRR is shown on Table 10-4.

(2) Cashflow

In 1999, the 16th year after commissioning, the debt service ratio will fall to 0.99 as shown in the Income Statement. After tiding over of the hardest year, NAPOCOR will be able to accumulate the profit of ₱8,566 million, or about 57 billion at the final year of operation after NAPOCOR would have paid up the loan repayment of the original and upgrading projects. Repayment Schedule, Income Statement and Cash Flow Statement are shown on Tables 10-5 to 10-7.

10-3-4 With/Without Financial Evaluation

After the upgrading project (With project) which intends the maximum use of the dear domestic coal, the influence of the upgrading project to the financial condition of the power plant (Without project) was studied with the result below.

		Without	With	Increase/Decrease
Plant efficiency	(%)	35.3	35.4	0.1
Capacity factor	(%)	68	70	+2
Generation	(GWh)	1.787	1.839	+52
Coal consumption	(t)	830,858	878,531	+47,673
		(100%)	(100%)	
Semirara coal (SSC)	(t)	415,429	518,333	+102,904
		(50%)	(59%)	
Australian coal	(t)	415,429	360,198	-55,231
		(50%)	(41%)	
Fuel cost	(10^3 Peso)	591,987	631,884	+39,897
	(Million Yen)	(3,947)	(4,213)	(+266)
Gen. cost	(₱/kWh)	0.6954	0.6982	+0.0028

The With and Without FIRR recorded 13.67% and 14.14%, respectively based on the conditions above.

As compared with the Without case, the With will bring about accumulated loss of ₱866 million or ¥5,774 million at the final year of the plant operation.

Table 10-4 Financial Evaluation of Calaca No. 1 Upgrading Project

FIRR = 13.67%

(Unit: 000 peso)

No	Year	Original Project Cost	Upgrade Project Cost	Fuel Cost Imported	Domestic	Other O & M	Cost Total	Salable Energy (mwh)	Power Rate (Peso/KWh)	Revenue	Balance
1	1984	6,032,056	0	35,624	46,325	6,397	6,120,402	161,967	0.9740	157,756	(5,962,646)
2	1985	0	0	407,978	282,587	49,820	740,385	1,261,487	1.2062	1,521,606	781,221
3	1986	0	0	384,213	295,174	55,231	734,618	1,398,516	1.0552	1,475,714	741,096
4	1987	0	0	280,415	311,572	61,331	653,318	1,398,516	1.0552	1,475,714	822,396
5	1988	0	0	280,415	311,572	61,331	653,318	1,497,388	1.0552	1,580,044	926,726
6	1989	0	0	280,415	311,572	61,331	653,318	1,497,388	1.0552	1,580,044	926,726
7	1990	0	438,878	280,415	311,572	61,331	1,092,196	1,497,388	1.0552	1,580,044	487,848
8	1991	0	0	243,134	388,750	63,135	695,019	1,541,428	1.0552	1,626,515	931,496
9	1992	0	0	243,134	388,750	63,135	695,019	1,541,428	1.0552	1,626,515	931,496
10	1993	0	0	243,134	388,750	63,135	695,019	1,541,428	1.0552	1,626,515	931,496
11	1994	0	0	243,134	388,750	63,135	695,019	1,541,428	1.0552	1,626,515	931,496
12	1995	0	0	243,134	388,750	63,135	695,019	1,541,428	1.0552	1,626,515	931,496
13	1996	0	0	243,134	388,750	63,135	695,019	1,541,428	1.0552	1,626,515	931,496
14	1997	0	0	243,134	388,750	63,135	695,019	1,541,428	1.0552	1,626,515	931,496
15	1998	0	0	243,134	388,750	63,135	695,019	1,541,428	1.0552	1,626,515	931,496
16	1999	0	0	243,134	388,750	63,135	695,019	1,541,428	1.0552	1,626,515	931,496
17	2000	0	0	243,134	388,750	63,135	695,019	1,541,428	1.0552	1,626,515	931,496
18	2001	0	0	243,134	388,750	63,135	695,019	1,541,428	1.0552	1,626,515	931,496
19	2002	0	0	243,134	388,750	63,135	695,019	1,541,428	1.0552	1,626,515	931,496
20	2003	0	0	243,134	388,750	63,135	695,019	1,541,428	1.0552	1,626,515	931,496
21	2004	0	0	243,134	388,750	63,135	695,019	1,541,428	1.0552	1,626,515	931,496
22	2005	0	0	243,134	388,750	63,135	695,019	1,541,428	1.0552	1,626,515	931,496
23	2006	0	0	243,134	388,750	63,135	695,019	1,541,428	1.0552	1,626,515	931,496
24	2007	0	0	243,134	388,750	63,135	695,019	1,541,428	1.0552	1,626,515	931,496
25	2008	0	0	243,134	388,750	63,135	695,019	1,541,428	1.0552	1,626,515	931,496
26	2009	0	0	182,351	291,563	63,135	537,048	1,156,071	1.0552	1,219,886	682,838
Total		6,032,056	438,878	6,508,238	9,159,437	1,556,337	23,694,945	37,614,425		39,868,078	16,173,133

Table 10-5 Repayment Schedule

Original Project Loan terms	
Grace period	3.5 Year
Repayment	12 Year
Interest	8.5%p.a.

Upgrading Project Loan terms	
Grace period	3.5 Year
Repayment	12 Year
Interest	8.5%p.a.

(Unit: 000 peso)

		ORIGINAL PROJECT						UPGRADING PROJECT						TOTAL				
No	Year	Original Project Cost	Interest Grace period	Interest	Principal	Repayment	Outstanding Balance	Upgrade Project Cost	Interest Grace period	Interest	Principal	Repayment	Outstanding Balance	Interest Grace period	Interest	Principal	Repayment	Outstanding Balance
1	1984	6,032,056	256,362	0	0	0	6,288,418	0	0	0	0	0	0	256,362	0	0	0	6,288,418
2	1985	0	534,516	0	0	0	6,822,934	0	0	0	0	0	0	534,516	0	0	0	6,822,934
3	1986	0	579,949	0	0	0	7,402,883	0	0	0	0	0	0	579,949	0	0	0	7,402,883
4	1987	0	629,245	0	0	0	8,032,128	0	0	0	0	0	0	629,245	0	0	0	8,032,128
5	1988	0	0	682,731	410866	1,093,597	7,621,262	0	0	0	0	0	0	0	682,731	410,866	1,093,597	7,621,262
6	1989	0	0	647,807	445790	1,093,597	7,175,472	0	0	0	0	0	0	0	647,807	445,790	1,093,597	7,175,472
7	1990	0	0	609,915	483682	1,093,597	6,691,790	438,878	18,652	0	0	0	457,530	18,652	609,915	483,682	1,093,597	7,149,320
8	1991	0	0	568,802	524795	1,093,597	6,166,995	0	38,890	0	0	0	496,420	38,890	568,802	524,795	1,093,597	6,663,415
9	1992	0	0	524,195	569402	1,093,597	5,597,593	0	42,196	0	0	0	538,616	42,196	524,195	569,402	1,093,597	6,136,209
10	1993	0	0	475,795	617802	1,093,597	4,979,791	0	45,782	0	0	0	584,398	45,782	475,795	617,802	1,093,597	5,564,189
11	1994	0	0	423,282	670315	1,093,597	4,309,476	0	0	49,674	29,893	79,567	554,505	0	472,956	700,208	1,173,164	4,863,981
12	1995	0	0	366,305	727292	1,093,597	3,582,184	0	0	47,133	32,434	79,567	522,071	0	413,438	759,726	1,173,164	4,104,255
13	1996	0	0	304,486	789111	1,093,597	2,793,073	0	0	44,376	35,191	79,567	486,880	0	348,862	824,302	1,173,164	3,279,953
14	1997	0	0	237,411	856186	1,093,597	1,936,887	0	0	41,385	38,182	79,567	448,698	0	278,796	894,368	1,173,164	2,385,585
15	1998	0	0	164,635	928962	1,093,597	1,007,925	0	0	38,139	41,428	79,567	407,270	0	202,774	970,390	1,173,164	1,415,195
16	1999	0	0	85,674	1007925	1,093,599	0	0	0	34,618	44,949	79,567	362,321	0	120,292	1,052,874	1,173,166	362,321
17	2000	0	0	0	0	0	0	0	0	30,797	48,770	79,567	313,551	0	30,797	48,770	79,567	313,551
18	2001	0	0	0	0	0	0	0	0	26,652	52,915	79,567	260,636	0	26,652	52,915	79,567	260,636
19	2002	0	0	0	0	0	0	0	0	22,154	57,413	79,567	203,223	0	22,154	57,413	79,567	203,223
20	2003	0	0	0	0	0	0	0	0	17,274	62,293	79,567	140,930	0	17,274	62,293	79,567	140,930
21	2004	0	0	0	0	0	0	0	0	11,979	67,588	79,567	73,342	0	11,979	67,588	79,567	73,342
22	2005	0	0	0	0	0	0	0	0	6,234	73,342	79,576	0	0	6,234	73,342	79,576	0
23	2006	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24	2007	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
25	2008	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26	2009	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total		6,032,056	2,000,072	5,091,038	8,032,128	13,123,166	80,408,811	438,878	145,520	370,415	584,398	954,813	5,850,391	2,145,592	5,461,453	8,616,526	14,077,979	86,259,202

Table 10-6 Income Statement

(Unit: 000 peso)

No	Year	Salable Energy	Power Rate	Revenue	Fuel	O & M	Depreci-ation	Operating Income	Financial Expense (Interest)	Net Income	Accumulated Net Income	Internal Cash Generation	Accumulated Cash Generation	Accumulated Repayment	Debt Service Ratio
1	1984	161,967	0.9740	157,756	81,949	6,397	0	69,410	0	69,410	69,410	69,410	69,410	0	-
2	1985	1,261,487	1.2062	1,521,606	690,565	49,820	524,841	256,380	0	256,380	325,790	781,221	850,631	0	-
3	1986	1,398,516	1.0552	1,475,714	679,387	55,231	573,170	167,926	0	167,926	493,716	741,096	1,591,727	0	-
4	1987	1,398,516	1.0552	1,475,714	591,987	61,331	602,967	219,429	0	219,429	713,145	822,396	2,414,123	0	-
5	1988	1,497,388	1.0552	1,580,044	591,987	61,331	575,559	351,167	682,731	(331,564)	381,581	926,726	3,340,849	1,093,597	3.05
6	1989	1,497,388	1.0552	1,580,044	591,987	61,331	548,152	378,574	647,807	(269,233)	112,348	926,726	4,267,575	2,187,194	1.95
7	1990	1,497,388	1.0552	1,580,044	591,987	61,331	539,521	387,205	609,915	(222,710)	(110,362)	926,726	5,194,301	3,280,791	1.58
8	1991	1,541,428	1.0552	1,626,515	631,884	63,135	516,434	415,062	568,802	(153,740)	(264,102)	931,496	6,125,797	4,374,388	1.40
9	1992	1,541,428	1.0552	1,626,515	631,884	63,135	493,695	437,801	524,195	(86,394)	(350,496)	931,496	7,057,293	5,467,985	1.29
10	1993	1,541,428	1.0552	1,626,515	631,884	63,135	471,354	460,142	475,795	(15,653)	(366,149)	931,496	7,988,789	6,561,582	1.22
11	1994	1,541,428	1.0552	1,626,515	631,884	63,135	443,627	487,869	472,956	14,913	(351,236)	931,496	8,920,285	7,734,746	1.15
12	1995	1,541,428	1.0552	1,626,515	631,884	63,135	415,901	515,595	413,438	102,157	(249,079)	931,496	9,851,781	8,907,910	1.11
13	1996	1,541,428	1.0552	1,626,515	631,884	63,135	388,174	543,322	348,862	194,460	(54,619)	931,496	10,783,277	10,081,074	1.07
14	1997	1,541,428	1.0552	1,626,515	631,884	63,135	360,447	571,049	278,796	292,253	237,634	931,496	11,714,773	11,254,238	1.04
15	1998	1,541,428	1.0552	1,626,515	631,884	63,135	332,721	598,775	202,774	396,001	633,635	931,496	12,646,269	12,427,402	1.02
16	1999	1,541,428	1.0552	1,626,515	631,884	63,135	304,994	626,502	120,292	506,210	1,139,845	931,496	13,577,765	13,600,568	0.9983
17	2000	1,541,428	1.0552	1,626,515	631,884	63,135	277,267	654,229	30,797	623,432	1,763,277	931,496	14,509,261	13,680,135	1.06
18	2001	1,541,428	1.0552	1,626,515	631,884	63,135	249,540	681,956	26,652	655,304	2,418,581	931,496	15,440,757	13,759,702	1.12
19	2002	1,541,428	1.0552	1,626,515	631,884	63,135	221,814	709,682	22,154	687,528	3,106,109	931,496	16,372,253	13,839,269	1.18
20	2003	1,541,428	1.0552	1,626,515	631,884	63,135	194,087	737,409	17,274	720,135	3,826,244	931,496	17,303,749	13,918,836	1.24
21	2004	1,541,428	1.0552	1,626,515	631,884	63,135	166,360	765,136	11,979	753,157	4,579,401	931,496	18,235,245	13,998,403	1.30
22	2005	1,541,428	1.0552	1,626,515	631,884	63,135	138,634	792,862	6,234	786,628	5,366,029	931,496	19,166,741	14,077,979	1.36
23	2006	1,541,428	1.0552	1,626,515	631,884	63,135	110,907	820,589	0	820,589	6,186,618	931,496	20,098,237	14,077,979	-
24	2007	1,541,428	1.0552	1,626,515	631,884	63,135	83,180	848,316	0	848,316	7,034,934	931,496	21,029,733	14,077,979	-
25	2008	1,541,428	1.0552	1,626,515	631,884	63,135	55,453	876,043	0	876,043	7,910,977	931,496	21,961,229	14,077,979	-
26	2009	1,156,071	1.0552	1,219,886	473,913	63,135	27,730	655,108	0	655,108	8,566,085	682,838	22,644,067	14,077,979	-
Total		37,614,425	27	39,868,078	15,667,674	1,556,337	8,616,529	14,027,538	5,461,453	8,566,085	53,119,316	22,644,067	22,644,067	14,077,979	

Table 10-7 Cash Flow Balance

(Unit: 000 peso)

No	Year	Net Income	Depreciation	Capital Original Project	Capital Upgrading Project	Total Inflow	Capital Expenditure	Repayment (Principal)	Total Outflow	Annual Benefit	Accumulated Benefit
1	1984	69,410	0	6,032,056	0	6,101,466	6,032,056	0	6,032,056	69,410	69,410
2	1985	256,380	524,841	0	0	781,221	0	0	0	781,221	850,631
3	1986	167,926	573,170	0	0	741,096	0	0	0	741,096	1,591,727
4	1987	219,429	602,967	0	0	822,396	0	0	0	822,396	2,414,123
5	1988	(331,564)	575,559	0	0	243,995	0	410,866	410,866	(166,871)	2,247,252
6	1989	(269,233)	548,152	0	0	278,919	0	445,790	445,790	(166,871)	2,080,381
7	1990	(222,710)	539,521	0	438,878	755,689	438,878	483,682	922,560	(166,871)	1,913,510
8	1991	(153,740)	516,434	0	0	362,694	0	524,795	524,795	(162,101)	1,751,409
9	1992	(86,394)	493,695	0	0	407,301	0	569,402	569,402	(162,101)	1,589,308
10	1993	(15,653)	471,354	0	0	455,701	0	617,802	617,802	(162,101)	1,427,207
11	1994	14,913	443,627	0	0	458,540	0	700,208	700,208	(241,668)	1,185,539
12	1995	102,157	415,901	0	0	518,058	0	759,726	759,726	(241,668)	943,871
13	1996	194,460	388,174	0	0	582,634	0	824,302	824,302	(241,668)	702,203
14	1997	292,253	360,447	0	0	652,700	0	894,368	894,368	(241,668)	460,535
15	1998	396,001	332,721	0	0	728,722	0	970,390	970,390	(241,668)	218,867
16	1999	506,210	304,994	0	0	811,204	0	1,052,874	1,052,874	(241,670)	(22,803)
17	2000	623,432	277,267	0	0	900,699	0	48,770	48,770	851,929	829,126
18	2001	655,304	249,540	0	0	904,844	0	52,915	52,915	851,929	1,681,055
19	2002	687,528	221,814	0	0	909,342	0	57,413	57,413	851,929	2,532,984
20	2003	720,135	194,087	0	0	914,222	0	62,293	62,293	851,929	3,384,913
21	2004	753,157	166,360	0	0	919,517	0	67,588	67,588	851,929	4,236,842
22	2005	786,628	138,634	0	0	925,262	0	73,342	73,342	851,920	5,088,762
23	2006	820,589	110,907	0	0	931,496	0	0	0	931,496	6,020,258
24	2007	848,316	83,180	0	0	931,496	0	0	0	931,496	6,951,754
25	2008	876,043	55,453	0	0	931,496	0	0	0	931,496	7,883,250
26	2009	655,108	27,730	0	0	682,838	0	0	0	682,838	8,566,088
	Total	8,566,085	8,616,529	6,032,056	438,878	23,653,548	6,470,934	8,616,526	15,087,460	8,566,088	8,566,088

11. General Background of Semirara Coal Mine Survey

11-1 Background of JICA Survey

11-2 Development of Semirara Coal Mine

11-3 Coal Supply Agreement

11-4 Coal Sales Performance

11-5 Coal Price

11. General Background of Semirara Coal Mine Survey

11-1 Background of JICA Survey

As a part of the study of the Calaca Coal-Fired Thermal Plant No. 1 Unit upgrading project which JICA undertook on behalf of the National Power Corporation (NAPOCOR) of the Philippines, JICA coal survey team conducted the survey on the coal supplied to the above mentioned power plant as well as on the mining operations at the Semirara island where the coal is being produced.

The purpose of this survey is to find a way to maximize the consumption of the said coal at the power plant identifying the coal quality being produced at the Unong pit on the Semirara island as well as finding the way to upgrade the coal quality to a level acceptable to the power plant which would be modified to a certain extent to increase the consumption rate of the Semirara coal.

At the same time, mine production plan was studied to estimate the coal supply capability to ensure the fulfillment of the coal requirement to the power plant.

The Semirara Coal Mine is located on the Semirara island, approximately 300 km straight line distance to south from Manila, about 16 km south of the Mindoro island.

The island has an area of approximately 55 km^2, 13 km in length and 4 km in width. It is a very small island, but it has been known that the island has the largest coal reserves in the Philippines. The estimated reserves on the island amount to as much as 130 million tons which is approximately 40% of the nominally mentioned total proven coal reserve of about 300 million tons in the Philippines. Refer to Table 11-1 Summary of Reserves of Coal Regions.

There are three major coal reserve areas on the island, namely Unong, Himalian and Panian. The Unong area, amongst those three areas, has been developed by the Semirara Coal Corporation (SCC) at the same time when the Calaca Power Plant was constructed, aiming at supplying fuel coal mainly to the power plant.

The shipment of the coal produced at the Unong pit was started in July 1984 to be in time for the power plant start-up, however, the characteristics of the coal did not match to the standard on which the boiler had been designed, resulting in lower plant efficiency and less plant output than its design as well as causing troubles in the coal handling system. The troubles are considered to be attributed by mudstone contained in the product coal and in October 1984, NAPOCOR stopped taking coal from SCC.

Table 11-1 Summary of Coal Reserves by Regions

As of 30 June 1986

(Million metric tons)

	Resource Potential	Positive	Probable	In-Situ	Mineable Reserves
Semirara	550	132.28	29.76	152.12	129.30
Cagayan Valley	336	68.48	53.18	103.58	88.04
Southern Mindoro	100	3.07	1.40	4.01	2.40
Polillo-Batan-Catanduanes	17	6.49	4.44	9.46	7.70
Quezon	2	0.09	–	0.09	0.08
Negros	4.5	1.05	1.06	1.75	1.05
Northern Cebu	75	1.48	0.37	1.72	1.03
Central Cebu	40	2.27	0.15	2.37	1.42
Southern Cebu	50	3.94	2.38	5.53	3.32
Bohol	–	0.39	0.74	0.89	0.53
Davao	100	0.21	–	0.21	0.12
Surigao	209	30.45	23.38	46.04	34.28
Zamboanga	45	28.92	7.40	33.85	20.31
Samar-Leyte	27	4.50	4.45	7.47	6.35
Masbate	2.5	0.29	–	0.29	0.18
Total	1,558.0	283.91	128.71	369.37	296.11

Data Source: Ministry of Energy

In order to solve the problems, SCC altered its mining method at the Unong pit from the originally designed whole seam extraction, so called "run-of-mine" to selective mining to reduce the mudstone content in the product coal by removing the mudstone plies at the face as much as possible. Then, in February 1985, NAPOCOR resumed taking coal supply from SCC. In addition to the selective mining, SCC built a pilot coal washing plant aiming at the maximization of coal recovery by washing #11 ply, which is a low grade coal inter-bedded with carbonatious mudstone, and contaminated coal spilt out of the mining equipment. Those coals are called "washable coal" and after being washed, it is blended with the selective mining coal from the pit at a maximum rate of 10%.

In this survey, coal quality upgrading measures were studied on the coal produced at the Unong pit to maximize its usage at the power plant as well as mine production plans to ensure the coal supply required at the plant. According to the findings of the study, the optimum measures considered to be acceptable for both SCC and NAPOCOR are recommended.

The site survey was conducted twice, the first survey was in the periods of February 15 to March 29, 1987 and the second survey was from July 28 to August 26, 1987. During those periods, SCC permitted the entry to the mine site only 11 days for the first and 3 days for the second surveys and provided no requested data material. In the first survey, however, coal samples were taken from various locations in the Unong pit with the extensive assistance of SCC site personnel.

Some of the requested data materials were provided by SCC and reached to JICA survey team in early October 1987, as a result of NPC's continuous negotiations with SCC since the beginning of the JICA survey in February 1987.

The study was carried out based on the available information obtained through the brief site reconnaissance and the analysis data of the coal samples.

11-2 Development of Semirara Coal Mine

1) Calca Coal-Fired Thermal Power Plant

Following the government energy policy, the 300 MW coal-fired thermal power plant was conceived at Calaca, Batangas, Luzon. The power plant was scheduled to use 100 percent local coal to be produced at the Semirara coal mine, in accordance with the statement in the 1980–1989 energy program, which said: Philippine coal mined to date is generally subbituminous and belongs to the low and medium classification in terms of calorific values which varies from 7,500 to 11,000 Btu/lb. This heating potential, low compared to international levels, though, meets coal standards for power generation and cement manufacturing, particularly where quantity through modern production schemes are assured.

2) Semirara Coal Mine Development

In order to meet the projected coal requirement partly, the Semirara coal mining project was started in late 1979, aiming at supplying coal to the Calaca coal fired thermal power plant to be constructed at Calaca, Batangas, some 230 kilometer north of the Semirara island.

The Semirara island is a very small island with an area of 5,500 hectare, located at off the southeastern tip of the Mindoro island, however, the island is known for its largest coal reserves in the Philippines.

On the Semirara island, small scale coal mining had been going on, since long before the energy crisis in 1970's.

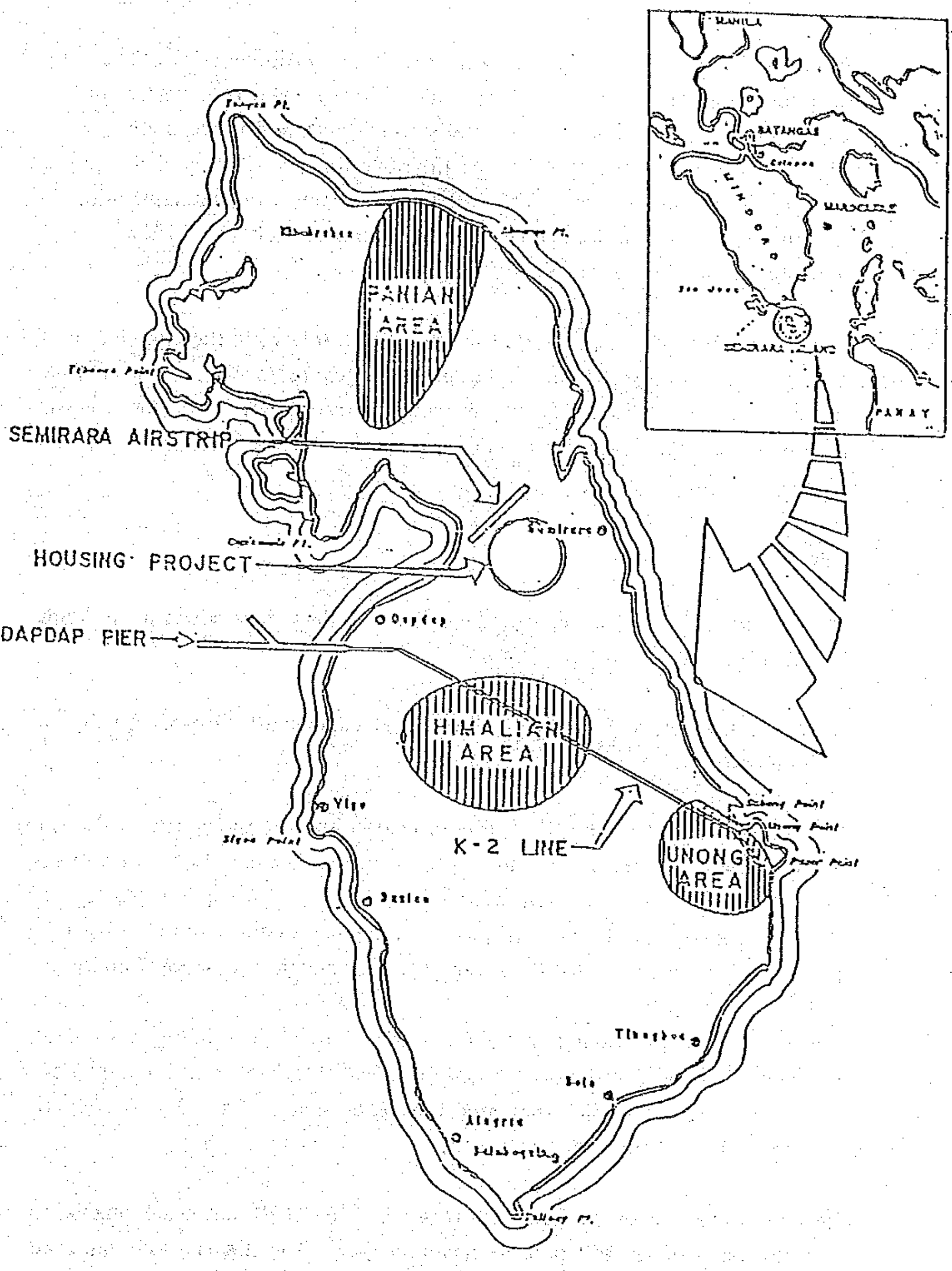
As indicated in Fig. 11-1, there are three coal reserves identified particularly rich in coal deposits, namely Unong, Panian and Himalian, amongst those the Unong area has been developed considering the easiest mining conditions.

Prior to the commencement of the development, the government as owner of the Semirara coal deposits and represented by the Board of Energy Development (BED) transferred the coal mining rights to a private consortium in July 1977. The consortium was composed of Vulcan Industrial and Mining Corp., Sulu Sea Oil Development Corp. (which later changed its name to the Energy Corp.) and Seafront Petroleum and Mineral Resources.

In 1978, the consortium, represented by Vulcan Industrial and Mining Corp., went into a contract with Austromineral G.m.b.H., Austria, a subsidiary of Vesto-Alpine AG, to conduct feasibility studies for the Unong and Panian coal reserve development including all mining related facilities on the isalnd.

The feasibility study was financed mainly by a long term loan from an Austrian bank.

In early 1980, the consortium formed a new entity, Semirara Coal Corporation (SCC) and transferred the coal mining right on the island to SCC.



SEMIRARA ISLAND

Fig. 11-1 Semirara Island Coal Reserves

In late 1980, SCC entered into a contract with Vesto-Alpine AG for the supply of mining equipment, mainly four units of bucket wheel excavator for the Unong open cast mining, coal hauling system, stacker and reclaimer system, shiploading facilities and the like. At the same time, SCC concluded a service contract with Austromineral G.m.b.H. for the engineering and supervision of the equipment installation, mine personnel training and management of the mine during the first year of the operation.

The mine construction was started in June 1980, following the completion of the engineering study. In the Unong pit, the opening up work had been done since 1979, and in 1984, four bucket wheel excavators were introduced in the pit upon the completion of the mining benches and the pit went into a full scale operation.

3) Coal Quality Problems

In July 1984, SCC began regular coal delivery to the Calaca power plant, being in time for the plant start-up.

Shortly after the plant start-up, NAPOCOR claimed the inferior quality of Semirara coal.

According to NAPOCOR, the Semirara coal contained too much mudstone, so called clay, and moisture, which clogged up the coal handling system in the plant, consequently NAPOCOR denounced that the power plant was unable to use Semirara coal 100 percent due to its inferior quality, and in November 1984, NAPOCOR suspended the acceptance of coal deliveries from Semirara.

The coal deliveries resumed in February 1985, after SCC modified its mining procedure from a whole seam extraction, so called "run-of-mine" to a selective mining in which coal plies and mudstone plies were extracted separately to minimize the mudstone contamination.

Because of the above mentioned reasons, NAPOCOR has been unable to operate the plant at 100 percent Semirara coal. The higher grade imported coal, mainly from Australia, has been blended with Semirara coal to cope with the above mentioned problems. It has been continued even after SCC modified its mining procedure, since the selectively mined Semirara coal results in unusually high alkalinity contents which cause slagging and fouling in the boiler.

11-3 Coal Supply Agreement

In December 1980, the coal supply agreement was signed between NAPOCOR and SCC to supply coal for a 300 megawatt coal-fired thermal power plant planned to be constructed and operated in Calaca, Batangas, Luzon, Philippines.

The required coal volume for the operation of the said power plant was estimated nine hundred thousand (900,000) metric tons per year.

In the "Coal Supply Agreement", details of the transactions are specified as follows:

1) Scope of Agreement

Subject to the terms and conditions of this Agreement, SCC agrees to sell and NAPOCOR agrees to buy from SCC the coal requirements of NAPOCOR for its 300 megawatt coal-fired thermal plant at Calaca, Batangas.

2) Contracted Quantity

SCC shall supply coal to NAPOCOR in the total annual of a minimum of nine hundred thousand (900,000) metric tons and maximum of nine hundred and sixty thousand (960,000) metric tons divided in equal monthly deliveries of seventy five thousand (75,000) to eighty thousand (80,000) metric tons per month according to NAPOCOR requirements.

3) Period of Contract

This "Coal Supply Agreement" shall remain in full force for a period of fifteen (15) years from the effectively of this Agreement unless terminated earlier by mutual agreement of both parties.

4) Specifications

Coal delivered to NAPOCOR shall have the following range of specifications:

a. Proximate Analysis (Air-dried basis as per ASTM)

Ash	16–22%
Fixed Carbon	24–30%
Volatile Combustible Matter	38–44%

	Sulfur	0.4–1.3%
	Moisture	11–15%
b.	Calorific Value (Air-dried basis)	8,300–9,300 Btu/lb.
c.	Hardgrove Grindability Index	40–50
d.	Ash Fusion	
	Hemisphere Temperature	1,350°C
	Flow Temperature	1,410°C
e.	Grain Size	200 mm maximum

5) Price

a. The base price of specification coal as of January 1, 1981 shall be two hundred ninety two pesos (₱292.00) per ton at eight thousand five hundred (8,500) Btu/lb, FOB Semirara.

b. NAPOCOR and SCC shall meet every six months from the effective date of the Agreement to fix the coal price for the succeeding six-month period based on a fair Philippine market price. The first meeting is scheduled in June 1981.

In the event the fair Philippine market price cannot be determined and/or agreed upon the following escalation formula shall be applied using the base price:

$$P = P_0 \times (0.100 + 0.270 \frac{*L}{L_0} + 0.288 \frac{**F}{F_0} + 0.342 \frac{***M}{M_0})$$

where,

P: Price FOB Semirara coal per ton

P_0: Base price of Semirara coal FOB Semirara as mutually agreed upon between SCC and NAPOCOR and as defined in Section (1) of this Article.

*L: Price index for labor at the period of price determination.

L_0: Price indix for labor as of January 1981.

**F: Price index for fuel at the period of price determination.

F_0: Price index for fuel as of January 1, 1981.

***M: Price index for materials at the period of price determination.

M_0: Price index for materials as of January 1981.

Note)

*: The arithmetic average of the price indices for salaries and wages for mining and quarrying as published by the Economic Research department, Central Bank of the Philippines.

**: The arithmetic average of the relative price of regular gasoline and diesel oil as published by the Economic Research Department, Central Bank of the Philippines.

***: The weighted average of the general wholesale price indices for processed goods in Metro Manila, particularly rubber and synthetic products, nonmetallic products, machineries, electrical machineries, and transport equipment as published by the Economic Research Department, Central Bank of the Philippines.

c. Any change in the price of the specification coal different from the derived price using the established base price and escalation formula, shall be subject to the approval of the President of the Republic of the Philippines.

d. The escalated price shall have a ceiling as determined by the import parity of Australian coal price calculated as follows:

$$P_C = (P_A + F_A)\frac{8{,}500}{H_A} - F_S$$

where,

P_C: Calculated ceiling price of Semirara coal, FOB, adjusted to Australian parity coal price, ₱/ton.

P_A: Average Australian FOB coal price in ₱/ton.

H_A: Average calorific value of Australian coal, in Btu/lb.

F_A: Average freight cost per metric ton of coal from Australia to Calaca, Batangas as determined by current rates of applicable maritime conference, ₱/ton.

F_S: Freight cost per metric ton of coal from Semirara to Calaca, Batangas per PNOC-NPC lighterage contract, ₱/ton.

The ceiling FOB price of Semirara coal shall be determined every six (6) months after the effective date of this Agreement. The data used for the computation of the ceiling price shall be the average of three (3) major Australian coal producers/exporters determined by the National Coal Authority and agreed upon by NAPOCOR and SCC.

6) Delivery Schedule

a. SCC shall deliver at Semirara pier within approximately eight (8) weeks before October 1, 1983 at which date the said delivery shall be complete, a total of One Hundred Thousand (100,000) metric tons of coal at the specification mentioned above which shall be needed and used in the initial firing of the first unit of the Batangas Coal-fired Thermal Plant.

b. Subsequent coal deliveries after completion of the shipment of One Hundred Thousand (100,000) metric tons to be used for the initial firing of the first unit of the Batangas Coal-fired Thermal Plant shall be made conformably in the quantity and manner provided for in Section (2) hereof, the first shipment to commence in January 1984 but not later than July 1984.

c. SCC shall construct and maintain docking and ship loading facilities in Semirara for barges and ships able to load up to Ten Thousand (10,000) metric tons net at a rate of One Thousand (1,000) metric tons