THE INTERIM REPORT
FOR
THE FEASIBILITY STUDY
ON
EFFECTIVE UTILIZATION OF BANKO COAL
IN
THE REPUBLIC OF INDONESIA

(SUMMARY)

May, 1985

JAPAN INTERNATIONAL
COOPERATION AGENCY

THE INTERIM REPORT FOR THE FEASIBILITY STUDY ON EFFECTIVE UTILIZATION OF BANKO COAL IN THE REPUBLIC OF INDONESIA (SUMMARY)

In response to the request of the government of the Republic of Indonesia, the Government of Japan decided to conduct the Feasibility Study on Banko Coal Effective Utilization as one of the international cooperation programs for the social and economic development of developing countries.

Japan International Cooperation Agency (JICA), the official agency responsible for the implementation of the technical cooperation programs of the government of Japan, and Agency for the Assessment and Application of Technology (Badan Pengkajian dan Penerapan Teknologi: BPPT) as a counterpart agency concluded the Agreement (Scope of Work) on February 24, 1984.

The Institute of Energy Economics, Japan (IEE, Japan), as the consultant for the implementation of the Study, (Japanese Study Team), is undertaking the Study in close cooperation with the counterpart.

This Interim Report illustrates and reports the results of the strategic investigation (1st stage) carried out in FY 1984.

1. Outline of the Study

The objective of the Study is to establish an appropriate master plan of effective utilization of Banko coal and to examine its technical, economic and financial feasibility, including coal gasification test, and to prepare a proposed project.

TYPE OF PROGRAM	Government-sponsored technical cooperation
AGENCY FOR THE IMPLEMENTATION Japanese side Indonesian side	 JICA (Japan International Cooperation Agency) BPPT (Agency for the Assessment and Application of Technology)
OBJECTIVE	Feasibility study on effective utilization of Banko coal in Indonesia
COAL RESOURCES	Non-transportable brown coal reserved in Banko area of South Sumatra
APPLICATION TECHNOLOGY	Coal gasification
PRODUCTS	Synthetic fuel oil, chemicals
SCOPE OF THE STUDY	1) Market survey on alternative liquid fuel and basic chemicals in Indonesia 2) Survey on reserves, quality and mining cost of Banko coal 3) Survey on gasification characteristics of Banko coal, using a small scale test plant 4) Investigation of a master plan for effective utilization of Banko coal 5) Financial analysis and economic evaluation for proposed project
DURATION	1984 - 85 (5 years) 1) Strategic Investigation Stage: One year 2) Coal Gasification Test Stage : 2.5 years 3) Feasibility Study Stage : 1.5 years

2. Outline of the Strategic Investigation (1st stage)

(1) Objective of the strategic investigation

The strategic investigation in FY 1984 puts emphasis on establishment of an appropriate master plan of Banko coal effective utilization.

(2) Method of the strategic investigation

The Study encompasses a wide variety of subjects to be investigated because the production of synthetic fuel (methanol) from brown coal belongs to rather new technical and economic field and has less commercial experiences through the world.

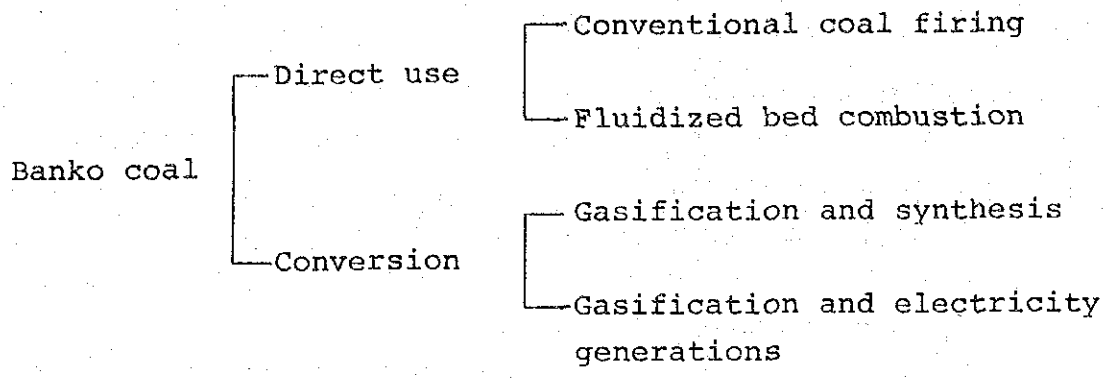
Therefore, the strategic investigation implemented in FY 1984 was planned to investigate the following principal elements by four of study teams.

1) Study team No. 1 : Preliminary survey on markets (May, June)
2) Study team No. 2 : Survey on Banko coal resources (July, Aug.)
3) Study team No. 3 : Survey on brown coal utilization technology (Sept. - Dec.)
4) Study team No. 4 : Strategic investigation on Banko coal effective utilization (Jan. - March)

The data and information collected and analyzed by study team No. 1 - No. 3 were synthesized and summerized into the master plan.

3. Scope of Study for Banko Coal Utilization

Principle technology of coal utilization was widely investigated and selected for Banko coal as follows:



Coke production and direct liquefaction were excluded from scope of study because:

Coke production : There is no technology for brown coal

Direct liquefaction : Technical development is still at the beginning stage of pilot plant and technical and economic data for a commercial plant can not be obtained for the time being.

4. Summary on Background, and Market Survey of Lignite and its Derivatives

(1) Background of this Study

1) Role of Crude oil

Production capacity of crude oil in Indonesia is estimated to be about 1,600 x 10^3 B/D and oil had 64% share in total export revenue in FY 1983.

2) Trend on domestic energy consumption

Domestic energy consumption has increased by 13.6%/yr. during ten years from 1972 to 1982. And also, share of oil in total energy consumption is as high as 80%. As a result of high increase rate of domestic oil consumption and level off in crude oil production capacity, oil export is declining after 1977 of peak year.

Crude oil consumption in Indonesia has been slow in its increase trend these few years, because of high price policy.

3) Energy policy

The Government aims to decrease its oil dependence from 78% to 62% in 1988/89 at the end of REPELITA-IV through promotion of alternative energy sources to oil and energy conservation.

In REPELITA-IV, the economy and energy consumption is to grow by 5%/yr. and 7%/yr. respectively. On the other hand, domestic petroleum consumption is expected to grow by less than 3%/yr.

By these policies, oil export capability in Indonesia is expected to be assured in the level of above 1 million B/D.

4) Coal utilization policy

Alternative energy sources such as coal, hydro and geothermal are planned to be developed in REPELITA-IV and, above all, special emphasis is to be laid upon development of coal utilization.

5) Long-term prospect of energy supply and demand

Migas model which was jointly developed through the study on Indonesia Data Bank by Indonesia and Japan (JICA), was used in this long term demand projection.

According to long term energy projection, total commercial primary energy demand and petroleum products will increase by 6.8%/yr. and 5.0%/yr. respectively. Primary energy demand and oil demand in 1995 will be 2.36 times and 1.89 times respectively as large as that in 1982. These figures show that potential energy demand in Indonesia still remains bull. And therefore, demand for petroleum product would increase significantly than originally expected unless present high fuel-price policy and development of alternative energy resources are retained.

Exogenous Variables Used in Long-term Projection of Energy Supply and Demand

	%/Yr. 1995/82	Remarks
Growth rate of crude oil production	0.35	1982; 133.7 $\times 10^4$ B/D 1995; 140 $\times 10^4$ B/D
Growth rate of exported crude oil price	3.5	29.53 $/BBL ('83)
Deflator for agricultural goods export price	7.1	
Index for international export price	7.1	
Exchange rate of Rp. relative to U.S.$	-5	
Population	2.0	2.3 (80/71) 158 million ('83)
Government consumption expenditure	14.0	6831 x 10^9 Rp. ('82)

Long-term Prospect of Energy Supply and Demand

	1982			1995			95/82 (%/yr)
	10^3tce	Physical Unit	%	10^3tce	Physical Unit	%	
National Gas	12,781		23.1	21,968		16.8	4.3
Coal	217		0.4	19,160		14.6	41.2
Hydro Power	1,060		1.9	10,626		8.1	19.4
Geo-thermal	0		0	1,029		0.8	-
Oil	41,357	206,371 565 x 10^3 B/D	74.6	78,073	389,584 1067 x 10^3 B/D	60.0	5.0
Grand Total	55,415	276,521 758 x 10^3 B/D	100	130,856	652,971 1789 x 10^3 B/D	100	6.8

(2) Market Survey on Derivatives from Banko Coal

1) Utilization of direct combustion

There are coal-fired power plant construction plans of about 5,000 MW next decade and Banko coal utilization as a power generating fuel is very promising.

However the feasibility study on power generation through direct combustion or combined cycle with gasification at mine mouth should be necessary because of difficulty in long-distance transportation of Banko coal.

2) Methanol as fuel for specific usage

Methanol production from synthesis gas is promising as an alternative fuel to oil and especially there would be very big economic impact by substituting methanol for diesel oil, which has big domestic demand for power generation.

3) Methanol for blended gasoline

R&D activities in some western countries are active for methanol blended gasoline these days. As a matter of fact, blending methanol with gasoline (about 3% of blending ratio) is being considered also in Indonesia.

4) Fertilizer

Domestic demand for fertilizer has been growing by as high as 10%/yr. Though natural gas has been used as its feedstock, the feedstock price for fertilizer company has been kept in low level from policy consideration. If this feedstock price should be decontrolled and increased to international market price level, fertilizer production from synthesis gas via coal could find some outlet in domestic market.

5. Results of Survey on Banko Coal Resources and Preliminary Estimation of its Mining Cost

The major objectives of the survey were as follows:

a) To clarify Banko coal resources and its quality

b) To grasp preliminarily coal mining cost.

(1) Coal reserves in Banko area

Coal exploration in Banko area was carried out by Shell in 1974 through 1978.

The survey revealed the following amount of coal reserves in Banko area (up to 100 m in depth).

COAL RESERVES IN BANKO AREA

Area	Measured Reserves 10^6 tons	Strip Ratio m^3/t coal	Coal Quality
Block A (North West Banko)	129.5	2.0	Total Moisture 28 - 35%
Block B (West & Central Banko)	178.5	1.5	Ash 4 - 16% (dry base)
Block C (Central Banko)	127.5	2.5	Volatile Matter 40.5-48.5% (dry base)
Total	435.5	-	Total Sulfur 0.15-2.4% (dry base)
			Calorific value 6100 - 7100 (dry base)

(2) Coal quality in Banko area

1) Banko coal is classified into non-transportable coal because of such troublesome features as its easy spontaneous combustion, fragility during transportation and stock, and high moisture content.

2) Banko coal contains high Na_2O of more than 0.6% within coal and ash fusion temperature of some coal seams is very low (around 1,150°C). Therefore fouling and slagging may be caused on tubes in case of a conventional boiler.

3) Coal quality of North West Banko is summarized by Shell as follows:

COAL QUALITY OF NORTH WEST BANKO COAL

(Average coal, dry base)

Ash (%)	6.7	
Volatile Matter (%)	45.4	
Gross C.V. (Kcal/kg)	6820	
Total Sulphur (%)	0.59	
In-situ Moisture (%)	25-35	(Range)
Sodium Oxide in Ash (%)	4-40	(Range)
" " below 40 m (%)	12	(Average)

(3) Site Reconnaissance and Chip Sampling

1) Outcrops and chip sampling

Slight amounts of coal samples were taken from shallow underground of 12 outcrops in the Banko, Suban Jeriji and Baturaja areas.

The analysis data suggest that the weathering of all samples has advanced because of sampling from near surface of the outcrops.

2) Study on sampling spot and method for coal gasification test.

Considering the purpose of coal gasification test, further study for selection of sampling spots and method shall be carried out in FY 1985, using small boring machine.

a) Analysis for an affect of weathering vs depth using small boring machine (up to 50 m depth)

b) To find out outcrops of each coal seem using small diameter auger drillings (up to 10 m depth)

c) To decide sampling spot and method based on a) and b)

(4) Preliminary study on plant site

During site reconnaissance, possible plant sites for commercial plants have been visited.

a) Banko site
b) Lematang River site
c) Musi River site

Considering major conditions for plant site selection such as distance to mining area, availability of river water and arranged infrastructures, Banko site seems to be the most potential candidate at this moment.

(5) Preliminary Estimation of Coal Mining Cost

1) Mining conditions and parameters

Mining conditions and mining parameters were studied as *pre-conditions for preliminary cost estimation of coal* mining.

i) Mining conditions

a) Coal prospect : North West Banko (Block A)

b) Mining area : about 4 km^2
Strike side length: about 8 km
Width (average) : 520 m

c) Mining depth : 100 m

d) Dip : 10 - 15°

e) High wall angle : 20°

f) Strip ratio (actual): 2.82 bank m^3/t. coal.

g) Overburden materials: Clay stone and tuff

ii) Mining parameters

a) Coal reserves in situ: 123 million tons

b) Minable coal : 98 million tons assuming
wheathering loss of 5%
geological loss of 10%
mining loss of 5%

c) Coal production (assumed): 3 million tons/year

d) Mine life : 33 years

e) Required processing materials
Coal as product : 2.3 million bank m^3/year
Overburden as spoil: 8.5 million bank m^3/year
(Total: 10.8 million bank m^3/year)

2) Conceptual plan of coal mining method
Conceptual plans of two different types, continuous mining method and non-continuous mining method are studied based on the above conditions and parameters.

i) Continuous mining method

a) Equipment and system
Bucket wheel excavators: For digging and loading
Belt conveyors : For transportation

b) Face arrangement : Five tiers of benches and faces in five blocks

c) Actual equipment driving hours:
3,863 hours/year assuming 3 shift operation and suspending time of 1605 hr due to rainfall.

d) Required capacity for equipment design:
2,800 bank m^3/hr

e) Major equipment design
Bucket wheel excavators
Nominal cutting capacity: 1,000 bank m^3/hr.
unit
Total units : 5 (4 in operation)

Face conveyors and cross pit conveyors

Capacity : 2,000 losse m^3/hr x 5 units

Total length : 10,800 m

Trunk belt conveyors and overland belt conveyors

Capacity : 4,000 loose m^3/hr x 3 units

Total length : 9,600 m

f) Manpower planning : 1,289 persons

ii) Non-continuous mining method

a) Equipment and system

Rope shovels : For digging and loading

Rear dump trucks : For face transportation

Belt conveyors : For overland transportation

b) Face arrangement : Six tiers of benches and faces in four blocks.

c) Actual equipment driving hours: 3,018 hours/year assuming 3 shift operation and suspending time of 1,566 hr due to rainfall.

d) Required capacity for equipment design: 3,580 bank m^3/hr

e) Major equipment design

Rope shovels

Bucket capacity: 13 m^3

Total units : 6 (5 in operation)

Rear dump trucks

Nominal capacity: 77 tons per unit

Total units : 29 (23 in operation)

Belt conveyors (coal)

Capacity : 2,800 loose m^3/hr

Total length : 1,500 m

Belt conveyor (spoil)

Capacity : 5,600 loose m^3/hr

Total length : 1,500 m

f) Manpower planning : 1,000 persons

3) Preliminary estimation of coal mining cost

i) Assumptions for coal mining cost

a) Equipment and facilities cost: Based on the costs in Japan in the second quarter of 1984 and no price escalation.

b) Funds : 100% on loan

c) Depreciation:

Period: Service life for equipment and 33 years for facilities

Method: Straight line method

d) Interest: 10 percent per year for depreciated value (assumed as 50% of initial investment for each year)

e) Labor cost: 3,300,000 Rp per year

f) 1 US$ = 240 Yen = 960 Rp

ii) Continuous mining method

a) Investment

Initial investment	158 x 10^6US$
Additional investment (up to 30th year)	128 "
Total	286 "

b) Coal mining cost

Operating/labor	4.13	US$/ton-coal
Depreciation	6.80	"
Interest	3.03	"
Administration	3.28	"
Total	19.70	"

iii) Non-continuous mining method

a) Investment

Initial investment	61 x 10^6	US$
Additional investment (up to 30th year)	184	"
Total	245	"

b) Coal mining cost

Operation/labor	6.58	US$/ton-coal
Depreciation	3.04	"
Interest	1.95	"
Administration	2.31	"
Total	13.88	"

iv) Above coal mining costs are not including costs for royalty, taxes if there are, and infrastructure such as housing, hospital, school and other necessary supporting facilities as well as costs for coal transportation over 1,500 m.
Also above preliminary cost estimations include some assumptions and preconditions as described in each chapter.
Therefore, needless to say, more accurate and rigid estimation is required for the feasibility study.

6. Results of Survey on Banko Coal Utilization Technology

The following fields of brown coal utilization technology were studied and it was clarified that commercial technology in each field is well developed and ready for commercialization.

a) Brown coal gasification technology
b) Technology for derivative production
c) Technology for electricity generation
d) Neat methanol engine

(1) Survey on coal gasification technology

1) Required performance for coal gasification technology
Required performances clarified by survey on market and coal resources are as follows:

a) To be superior for synthesis gas production to produce synthetic fuel oil and urea

b) To be superior for electricity generation

c) To be applicable for high sodium-in-ash and a wide range of ash fusion temperature as well as coal quality

2) Classification of coal gasification
More than ten of advanced coal gasification technology has been developed since the first oil crysis mainly in U.S.A., W. Germany, England and Japan and are evaluated to be ready for commercialization.

The reaction mechanism and structure of these advanced gasifiers are different, but can be classified into the four types.

a) Fixed bed gasifier
b) Fluidized bed gasifier
→ suitable for electricity generation

c) Entrained flow gasifier
d) Molten iron bath gasifier
→ available for synthesis and electricity generation

3) Technology development in Japan

In Japan, five types of coal gasification technology have been developed by Sun Shine project of MITI or private company.

i) CMRC/EPDC/NEDO

a) Air blow-pressurized type of fluidized bed gasifier having two reactors.
b) Development of coal gasification combined cycle system.
c) Under test operation using 40 T/day pilot plant.
d) Under basic design of 1,000 T/day demonstration plant.

ii) SUMITOMO Steel Industry

a) Oxygen blow atmospheric pressure type of molten iron bath gasifier
b) Production of synthesis gas
c) Completed the test operation using 60 T/day pilot plant
d) Under construction of 240 T/day demonstration plant with slightly pressurized type (Joint work with KHD of W. Germany)

iii) EPDC/NEDO

a) Oxygen blow-pressurized type of fluidized bed gasifier for coal and tar mixture
b) Production of town gas and fuel gas
c) Under test operation using 12 T/day pilot plant (20 T/day coal equivalent)

iv) CRIEPI/MHI

a) Air/oxygen blow-pressurized type of entrained flow gasifier

b) Production of fuel gas and synthesis gas

c) Under test operation using 2 T/day pilot plant

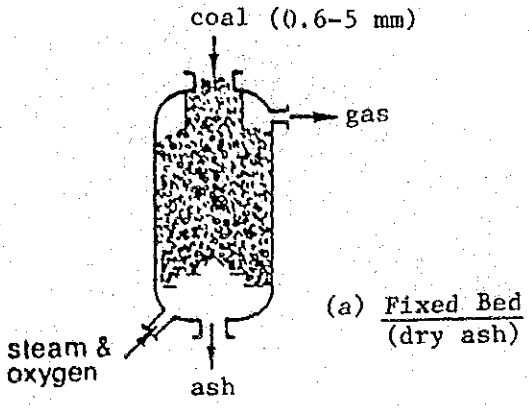
v) HITACHI/NEDO

a) Oxygen blow-pressurized type of entrained flow gasifier (two stage reaction in one reactor)

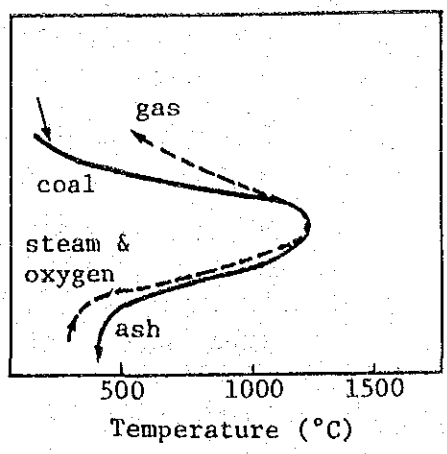
b) Production of fuel gas and synthesis gas

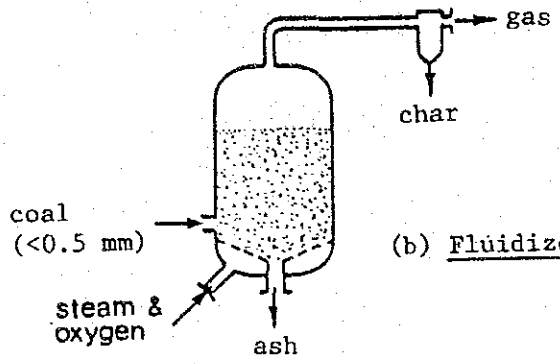
c) Under test operation using 1 T/day pilot plant

CLASSIFICATION OF PRINCIPAL COAL GASIFIER TYPES

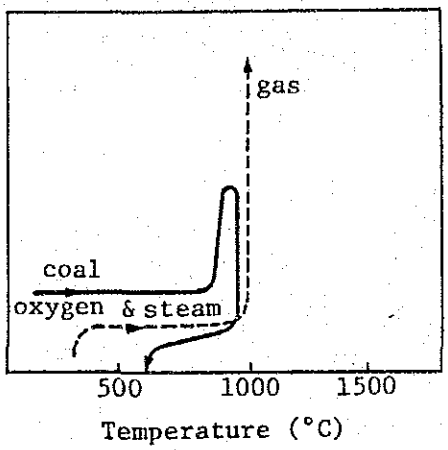


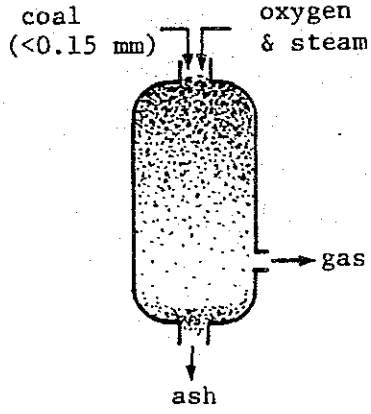
(a) Fixed Bed
(dry ash)



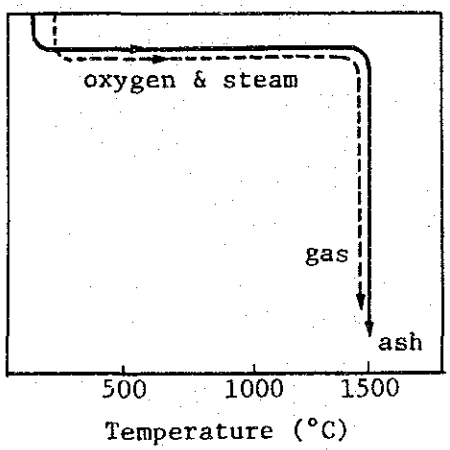


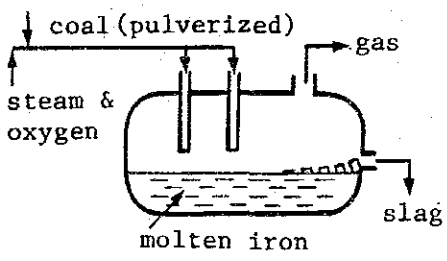
(b) Fluidized Bed



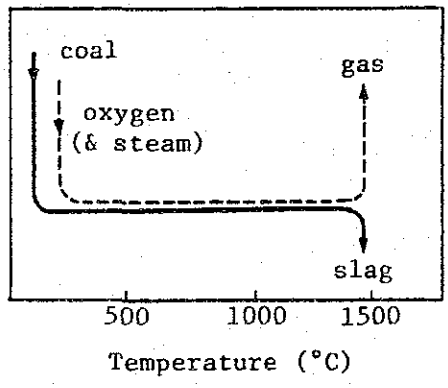


Entrained Flow





Molten Iron
Bath



SUMMARY OF OPERATIONAL AND PERFORMANCE CHARACTERISTICS
FOR JAPANESE GASIFIERS

	Fluidized Bed		Entrained flow		Molten Iron Bath
Name and/or Developpers	CMRC EPDC NEDO	-HYBRID- EPDC NEDO	CRIEPI MHI	HITACHI	-CGS PROCESS- SUMITOMO
Gasifying Medium	Air/Steam	O_2/Steam	Air, O_2/Steam	O_2/Steam	O_2
Coal Size & Feed Method					
-Size	1.5 mm	< 1 mm	200 mesh under 80-90 %	200 mesh under 70 %	200 mesh under 70 %
-Feed	Lock-hopper	Resid.Oil Slurry	Pneumatic	Pneumatic	Pneumatic
Ash State	Dry	Dry	Slag	Slag	Slag
Operating Press. & Temp.					
-Pressure kg/cm^{2}G	20	30	20	9	Atm.
-Temperature °C	840-920	750-950	1000-1600	1300-1600	1400-1600
Efficiencies					
-Carbon Conversion %	94	87.7		93	> 98
-Cold Gas Efficiency %	71	71.5		70	74-80
Steam & O_2 Requirement					
-Steam kg/kg-coal	1.0	2.2			0.05-0.15
-O_2 "	Air 2.1Nm^3	0.5-0.7		0.8	0.5
Gas Composition Typical (vol%,Dry)					
H_2	14.5	31	8.4	32.3	32.7
CO	9.2	14	18.1	55.0	61.1
CH_4	5.6	21	1.6	0.2	--
CO_2	16.5	32	8.0	12.4	3.0
N_2	53.3	--	60.7	--	--
Capacity T/D(One Unit)	40	20 (equivalent)	2	1	60
Application	Power	SNG	Power	Multi-use	Multi-use
Remarks	◦Combination with Dry Desulf. System ◦Two Stage F.B.	◦Coal:4 T/D H.Oil:8 T/D	◦Two Stage entrained flow -combustor -reductor	◦Two Stage Reaction	◦Lime & Flux ◦240 T/D Pilot Plant in Sweden under construction

CMRC: Coal Mining Research Center
EPDC: Erectric Power Develop, Co.
NEDO: New Energy Development Organization
CRIEPI: Central Research Institute for Erectric Power Industries
MHI: Mitsubishi Heavy Industries

CGS: Creative Gas and Steel

(2) Survey on technology for derivative production
The following technology was investigated, considering possibility of production in Indonesian.

a) Methanol as fuel and chemicals

b) Synthetic fuel oil (F/T process)

c) Ammonia and urea

d) Single cell protein

e) Gasoline from methanol (MTG process)

It was clarified that commercial technology for above products is well developed and ready for commercialization.

(3) Survey on technology for electricity generation

i) Conventional coal firing power plant
Banko coal is difficult to utilize in a conventional coal firing power plant, because high sodium-in-ash will cause severe fouling and slagging on heat transfer surfaces within the boiler.

ii) Fluidized bed combustion power plant
Fluidized bed combustion boiler seems to be suitable for Banko coal, because low combustion temperature eliminates the potential for fouling and slagging. The details will be studied in further study.

iii) Coal gasification combined cycle power plant
CGCC power plant seems to be more suitable for Banko coal, if high temperature gas turbine and hot gas clean-up system will be developed. However more concrete evaluation will be done in further study, watching the technical development.

(4) Survey on neat methanol engine

According to the market survey, it was pointed out that the production of fuel methanol is hopeful for substitution of diesel oil, especially for special-purpose-utilization such as electricity generator, city bus, agricultural equipment and mining equipment which are operated within rutined route. The objective of the survey was to cralify utilization technology of neat methanol as engine fuel.

1) Gas turbine

Gas turbine is highly suitable engine for neat methanol. In case of the existing gas turbine, neat methanol can be easily applied by minor changes of fuel supply system and combustion chamber.

2) Gasoline engine (Otto cycle)

Gasoline engine is also suitable engine for fuel methanol. However, commercial application of neat methanol car for multi-purpose utilization will not be easy because of "chicken and egg" dilemma between car manufacturers, methanol producers and methanol distributors.

3) Diesel Engine (Sabathe cycle)

Ordinary diesel engine is unsuitable engine for neat methanol because methanol is low in its cetane value.

However spark assist diesel engine developed by Komatsu in Japan can be applied for neat methanol as well as diesel oil.

It is notable that spark assist diesel engine designed for neat methanol has flexibility for fuel selection, neat methanol or diesel oil.

7. Preliminary evaluation of coal gasification technology

(1) Technology for synthesis gas production

All taking into the consideration, overall evaluation shows that oxygen blow-molten iron bath gasifier is superior for production of synthesis gas from Banko coal. Pressurized molten iron bath gasifier will be more better, if such a technology will be developed.

Evaluation of Coal Gasification Technology
for Synthesis Gas Production

	Fixed bed (dry ash)	Fludizied bed (oxygen blow)	Entrained flow (oxygen blow)	Molten iron bath (oxygen blow)
Gas composition	5	4	2	1
Impurity	4	3	2	1
Flexibility for coal quality	4	3	2	1
Overall thermal efficiency	3	2	3	1
Gas pressure	1	1	1	3
Operatability and safety	1	1	3	1
Construction cost	3	2	2	1
Commercial experience	1	1	1	2
Total	22	17	16	11
Overall evaluation (ranking)	4	2	2	1

(2) Technology for coal gasification combined cycle power generation

Overall evaluation shows that air blow-pressurized type of fluidized bed gasifier is superior for CGCC power generation, providing that the technical development of hot gas clean-up system will be completed.

Evaluation of Coal Gasification Technology for CGCC Power Generation

	Fixed bed (dry ash. air blow)	Fluidized bed (pressurized. air blow)	Entrained flow (pressurized. oxygen blow)	Molten iron bath (atm. pressure. oxygen blow)
Gas pressure	1	1	1	10
Oxygen.steam consumption	2	1	3	2
Tar content	3	1	1	1
Impurity	3	2	2	1
Gas calorific value	1	1	1	1
Carbon conversion	1	2	1	1
Operatability and safety	2	1	4	1
Construction cost (including air separation)	5	1	4	3
Commercial experience	1	1	1	2
Flexibility for coal quality	4	3	2	1
Total	23	14	20	23
Overall evaluation (ranking)	3	1	2	3

(3) Technology for coal gasification test

JICA study team and the counterpart (BPPT) have discussed and evaluated on the choice of the technology for the coal gasification test plant in PUSPIPTEK and agreed that the Molten Iron Bath process shall be selected.

The details of discussion are described on attached "Minutes of Meeting - Technology for coal gasification test plant" signed on Nov. 1, 1984.

Evaluation of Coal Gasification Technology for the Coal Gasification Test Plant

	Entrained Flow	Molten Iron Bath
Synthesis Gas Production		
CO and H2	o	o
Sulfur compounds	x	o
Flexibility for coal quality	x	o
Tested with Banko coal	x	o
Experience	o	x
Operatability	x	o
Maintenability	o	x
Technology transfer	x	o
Conclusion	x	o

Legend : o = good
x = average

8. Prospect of Effective Utilization of Banko Coal

(1) Technical feasibility of Banko coal utilization

1) Coal gasification and derivatives of synthesis gas
Coal gasification technology for production of synthesis gas, synthetic technology of derivative production and the utilization technology of derivatives production are well developed and ready for commercialization.

2) Direct combustion
It is evaluated that Banko coal is difficult to use in a conventional boiler because Banko coal contains high-sodium-in ash.
A fluidized bed combustion boiler seems to be superior for Banko coal because of its low combustion temperature. However the technical and economic feasibility shall be studied in further stage because the survey for the technology is insufficient at this moment.

3) Coal gasification combined cycle electricity generation
Coal gasification technology for CGCC is almost developed. However the technical development of high temperature gas turbine (1,300°C class) and hot gas clean-up system is still under development.
Therefore, the evaluation of technical feasibility will be carried out in due cource watching the development of above subjects.

(2) Economic Possibility of Banko Coal Utilization

1) Method of Study
For the time being, some of principal factors for financial and economic analysis are not yet studied. Therefore, the economic possibility is discussed on the basis of published literatures using the estimated preliminary selling price of Banko coal.

2) Estimated preliminary selling price of Banko coal

The selling price of Banko coal was preliminarily estimated on the basis of "cost and profit" for coal mining, because non-transportable coal can not be affected by the world market price. The formula is as follows:

$$\text{Selling price (dry base)} = \frac{A}{(1 - B)} \times (1 + C) \times (1 + D)$$

Here A : mining cost (wet base)
B : weight loss by drying (% of A)
C : drying cost (% of A)
D : profit (% of dry coal cost)

In case of Banko coal, each figure is as follows:

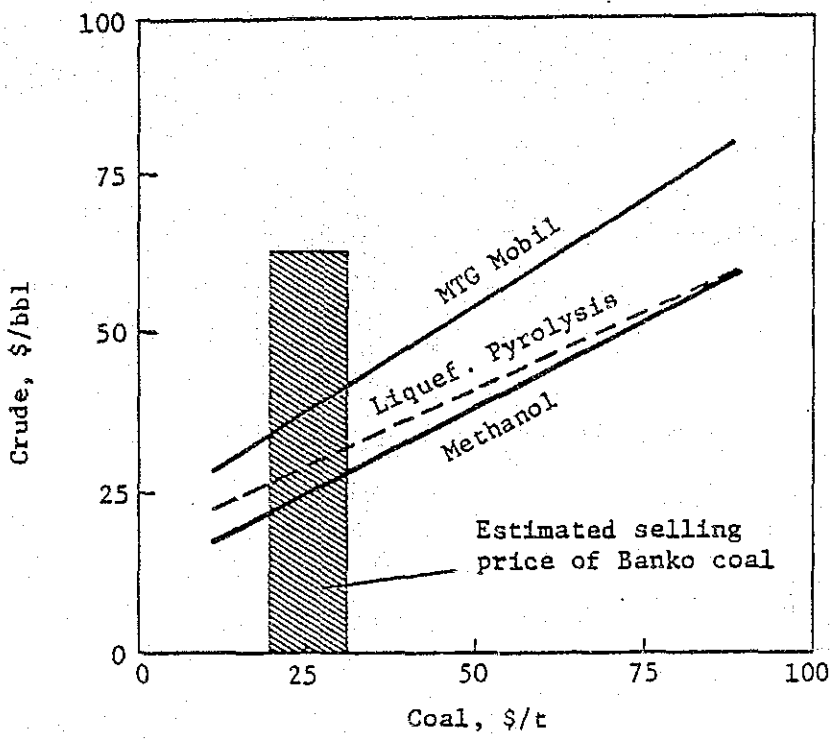
A = 14 $/ton : estimated for non-continuous method
B = 0.25) : estimated from coal quality
C = 0.10)
D = 0.20 : assumed

According to above formula and assumption, the estimated selling price of Banko coal is approximately 25 $/t (dry coal).

3) *Economic possibility of methanol production*

Production cost was estimated by correlation between *coal price and production cost of methanol* taken from Hydrocarbon processing. Aug., 1984.

Crude Oil/Synthetic Gasoline Equivalence (Coal)



The Source: Hydrocarbon Procersing. Aug., 1984.

25 $/ton of the estimated selling price of Banko coal gives approximate production cost as follows:

Methanol : equivalent to 25 $/bbl of crude oil

For the time being, the price of crude oil is FOB 27 - 29 $/bbl.

Therefore economic possibility of methanol production seems to be high, because it is estimated that the price of crude oil will be increased in future.

4) Economic possibility of methanol to gasoline (MTG)
The economics of MTG will be not feasible if the price of crude oil is not higher than 36 - 37 $/bbl. However, the merit of gasoline produced by MTG is not to require any special delivery facilities.

Therefore the economic feasibility will depend on the price prospect and Indonesian Government policy on price for petroleum gasoline.

5) Economic possibility of urea production
Production cost is estimated by correlation between coal price and production cost of urea taken from "Coal Gasification for Ammonia/Urea plant in Palembang" by Ir Kresno Sunarto and P.T. PUPUK SRIWIDJATA in May, 1983. 25 $/ton of coal price gives 160 $/ton of urea production cost. FOB price of urea in export market is around 170 - 180 $/ton for the time being. Therefore economic possibility of urea production from Banko coal depends on natural gas price in Indonesia.

6) Economic possbility of electricity generation
Coal gasification combined cycle electricity generation at mine mouth and supply to Java by high voltage direct current transmission line seems to be hopeful because the estimated coal price is enough low compared with exportable coal.
However, economic possibility of above system will be evaluated in further study, watching the technological development, especially 1,300°C gas turbine and hot gas clean-up system.

9. Master Plan for Banko Coal Effective Utilization

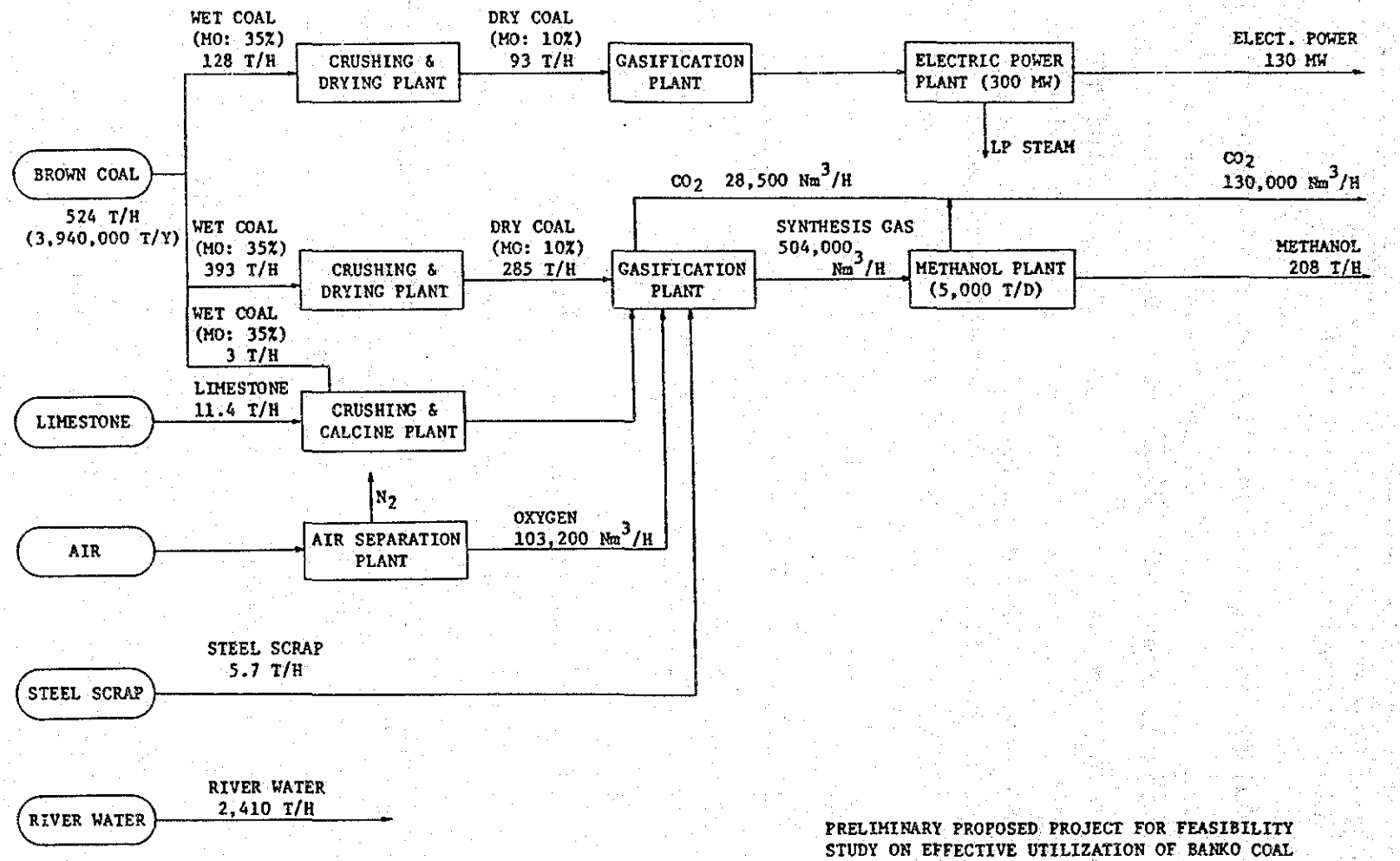
1) The following two cases were selected as principal utilization of Banko coal, reflecting the study results for market, coal resources and utilization technology.
   a) Fuel methanol and mine mouth power generation
   b) Fuel methanol, and urea, and mine mouth power generation

   Furthermore, according to the different capacities of mine mouth power generation, six cases of heat and material balances (required coal demand, production capacity and utilities consumptions) were studied to select the master plan.

2) According to the heat and material balance, all of six cases were evaluated to be available for commercialization.

3) As conclusion, the following two cases were selected as the master plan of Banko coal effective utilization. The suitable power generation capacity will be studied in further study, including the economics of high voltage transmission line.

Power generation capacity	MW	300	1,000
Required coal (wet)	million ton/year	3.9	6.0
(dry)	"	2.8	4.8
Methanol production	"	1.6	1.6
Quality of methanol	-	Chemical grade	Chemical grade
Electricity to JAWA	MW	85	800
Required cooling water	ton/hr	2,400	5,100



PRELIMINARY PROPOSED PROJECT FOR FEASIBILITY STUDY ON EFFECTIVE UTILIZATION OF BANKO COAL

10. Plan of Coal Gasification Test

(1) Objectives of coal gasification test are as follows;

1) To grasp the gasification characteristics of different type of brown coal reserved in Banko area.

2) To prepare necessary technical data for the feasibility study (3rd stage), synthesizing with existing large scale pilot plant data.

Note: The objective of the coal gasification test is not for the development of new technology nor collection of engineering data.

(2) Capacity of test facilities

The capacity of the test facilities is 20 kg/hr as coal feed rate.

Such a capacity was selected on the basis of sufficient capacity necessary to grasp characteristics of gasification of Banko coal.

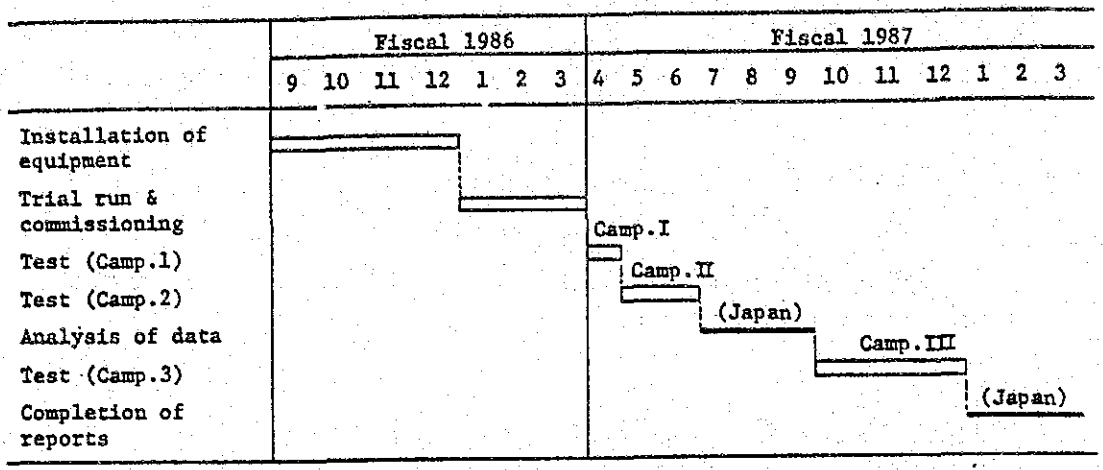
The basic specification required for the experimental equipment is as follows.

Basic specifications required for the experimental equipment

Item	Amount required	Remarks
Molten iron bath	300 kg	
Coal feeding rate	20 kg/h	Dry coal
Blowing oxygen	575 Nm^3/coal-t, 12 Nm^3/h	Standard value, varies with kind of coal.
Carrier gas	150 Nm^3/coal-t, 3 Nm^3/h	N_2
Product gas	2000 Nm^3/coal-t, 40 Nm^3/h	Standard value, varies with kind of coal.
Calcined lime	30 kg/coal-t, 0.6 kg/h	Standard value, varies with kind of coal.
Slag production	78 kg/coal-t, 1.6 kg/h	

(3) Test schedule

Overall schedule of Banko coal gasification experiment



It is so scheduled that installation, trial run and commissioning of the experimental equipment and also a cold test (drying, pulverizing and feeding of the actual Banko coal) will be completed at or before the end of March, 1987.

The gasification test will be conducted in a period of one year, from April, 1987 to March, 1988, and is divided into 3 steps of Campaign I to Campaign III by the purposes of the test.

During Campaign I, preparatory test will be conducted to examine and grasp the characteristics of the test facilities.

During Campaign II, essential test will be conducted to grasp the characteristics of Banko coal gasification.

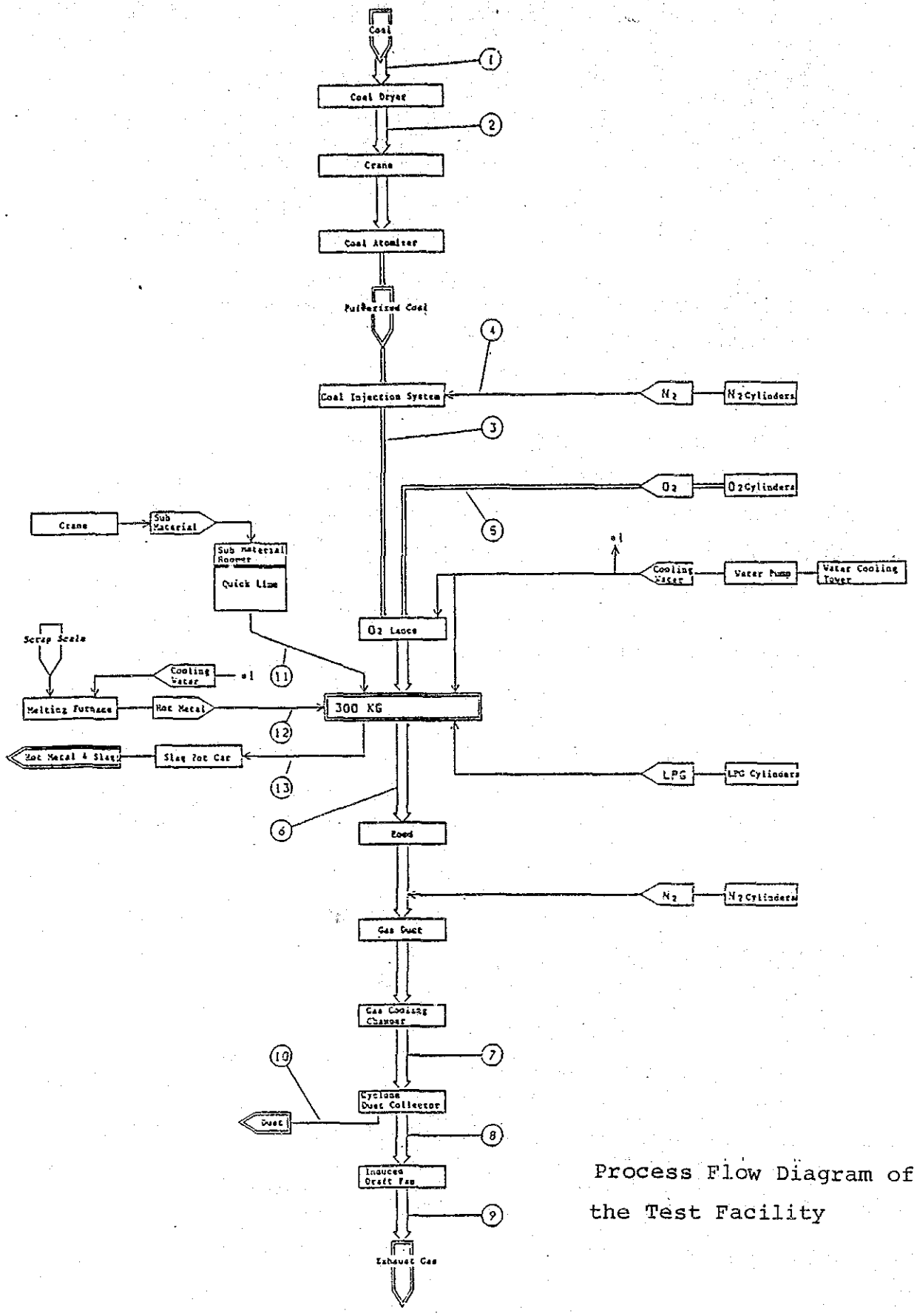
During Campaign III, supplementary experiment will be conducted in consideration of the results of previous test data.

(4) Basic design of the coal gasification test facilities

Basic design was carried out and the following technical information was clarified,

1) Basic design of the test facilities
   - i) Process design conditions
   - ii) Simplified process flow diagram
   - iii) Preliminary piping and instrument diagram
   - iv) Equipment list
   - v) General layout

2) Working plan of the counterpart



Process Flow Diagram of the Test Facility

11. Conclusion and Recommendation

(1) Conclusion

1) The stratigic investigation for effective utilization of Banko coal was carried out through FY 1984. The study includes the principal fields as follows:

   a) Preliminary market survey of Banko coal and its derivatives

   b) Survey on Banko coal resources and preliminary estimation of coal mining cost

   c) Survey on effective utilization technology

   d) Stratigic study for Banko coal effective utilization

   e) Study for coal gasification test

2) The most possible utilization of Banko coal is production of fuel mathanol, urea and electricity generation by coal gasification in view of market, technology, economics and Indonesian Government policy.

3) The measured reserves of Banko coal is enough for commercialization, 435 million tons. However the quality of Banko coal is "non-transportable-problem coal" because of spontaneous combustion and fragility during transportation and stock as well as high sodium-in-ash.

4) The preliminary mining cost of Banko coal is estimated as 14 $/t (wet base) by non-continuous mining method. The selling price is estimated as approximately 25 $/t (dry base) on the basis of "cost and profit" for coal mining.

5) Molten iron bath gasifier for synthesis gas production and fluidized bed gasifier for electricity generation are evaluated as the most superior technology for the time being.

6) It was revealed that spark assist diesel engine designed for neat methanol as fuel is ready for commercialization and has flexibility for fuel selection, diesel oil or neat methanol.

7) Master plan and preliminary proposed projects for Banko coal effective utilization were proposed.

   However such a plan and projects must be studied furthermore in due course.

8) Economic possibility of Banko coal utilization was studied on the basis of the estimated selling price of Banko coal and production cost data obtained from published literatures.

   Production of fuel methal is "hopeful", but MTG (mobil) and urea depend on price of crude oil in future and Government price policy for petroleum gasoline and natural gas.

   Possibility of electricity generation by CGCC depends on future's technical development.

9) As conclusion of the stratigic investigation, the effective utilization of Banko coal seems to be feasible in technical and economic stand point.

   Therefore it is recommended that the coal gasification test stage shall be proceeded as scheduled on Scope of Work.

(2) Recommendation

As the results of the stratigic investigation of effective utilization of Banko coal, the following subsidary subjects are proposed to be carried out in further study period.

1) Maps of Banko area will be prepared for the further study of coal sampling spot and method.

2) Water resources data and soil data will be additionally required for selection of plant site.

3) Market survey on fuel methanol for gas turbine generator and diesel engine generator as well as city bus in Indonesia will be carried out to grasp practical specified demand of fuel methanol.

4) Preliminary feasibility study on high voltage-direct current transmission line between Banko area and Java will be carried out to evaluate mine mouth electricity generation.