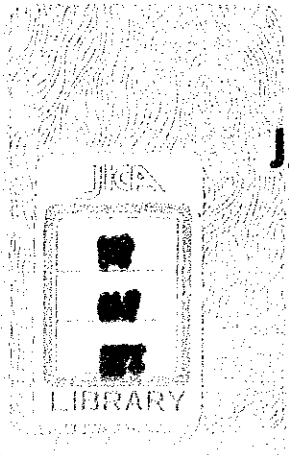
# THE INTERIM REPORT
# FOR
# THE FEASIBILITY STUDY
# ON
# EFFECTIVE UTILIZATION OF BANKO COAL
# IN
# THE REPUBLIC OF INDONESIA

## — STAGE II —
## (SUMMARY)

March, 1988

JAPAN INTERNATIONAL COOPERATION AGENCY



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# 1. CONCLUSION AND RECOMMENDATION

1. Gasification of Banko coal was technologically proven
2. The 3rd stage (feasibility study) would be carried out

1) Conclusion

i) This feasibility study was proposed by the State Minister for Research and Technology of Indonesia, Prof. Dr. Ing. B. J. Habibie.
The highlight of the study is the assessment and evaluation of gasification technologies for Banko coal.

ii) Technical reliability of Banko coal gasification by a molten iron bath process has been proven through the coal gasification test.

iii) The Master Plan of the Project is as follows:

| | | Base case | Alternative case |
|---|---|---|---|
| Coal feed rate | $10^6$ t/y | 4.2 | 4.5 |
| Methanol production | $10^6$ t/y | 1.6 | 1.3 |
| Urea production | $10^6$ t/y | – | 0.6 |
| Utilization of methanol | | Fuel for internal combustion engines. | |

iv) Initial fixed capital investment is appr. 1,100 billion Rupiah*.

v) IRR is 13%, if oil price is around 30 $/bbl.

2) Recommendation

The 3rd stage (feasibility study) of the Study would be carried out on the basis of the Scope of Work in FY 1988.

* Assumed exchange rates in the 2nd stage of the study are as follows:

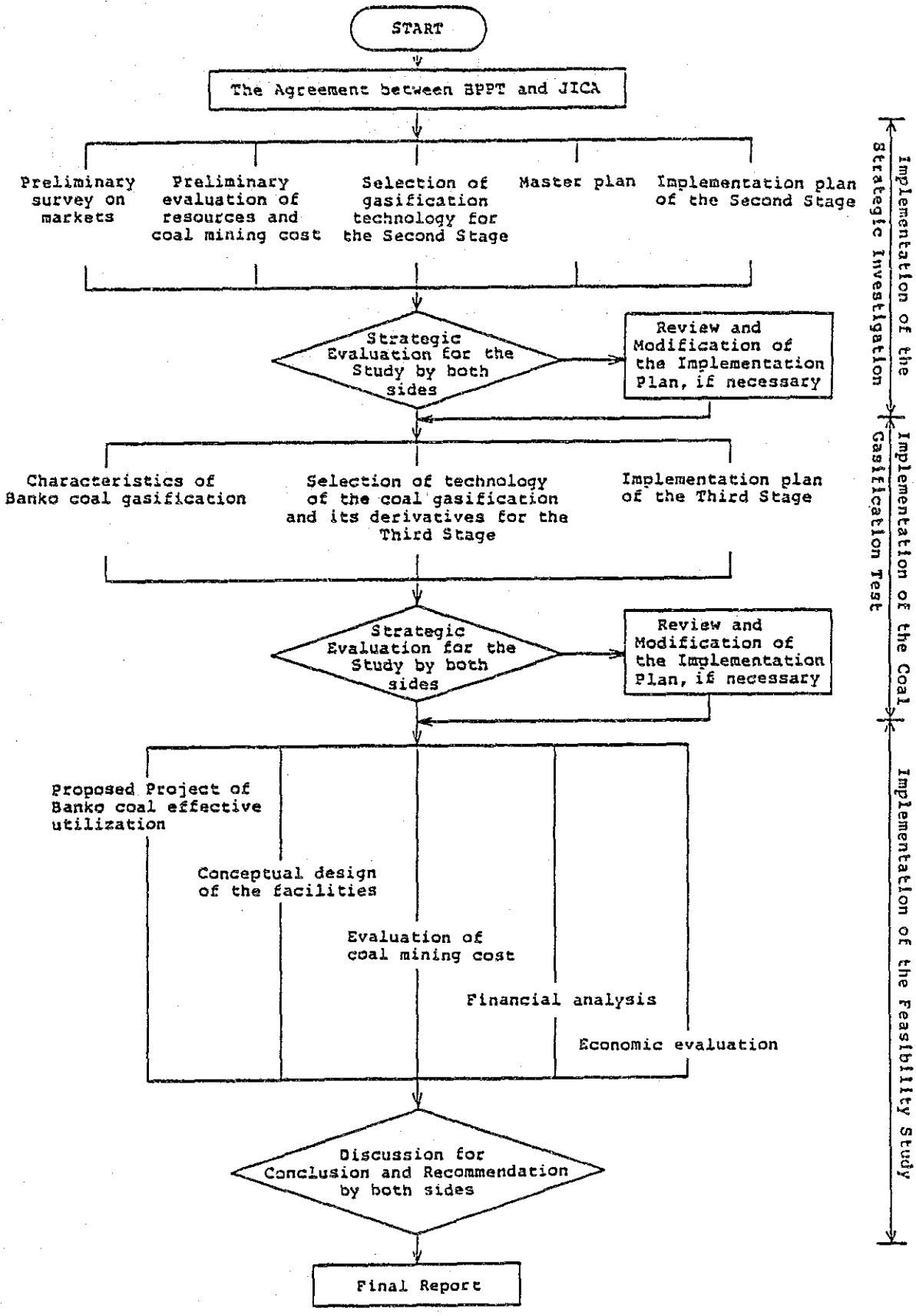
1 Rp = 0.18 ¥
1 US$ = 200 ¥

# 2. OUTLINE OF THE STUDY

To establish a master plan and examine its technical and economic feasibility

| TYPE OF PROGRAM | Government-sponsored technical cooperation |
|---|---|
| AGENCY FOR THE IMPLEMENTATION | |
| Japanese side | JICA (Japan International Cooperation Agency) |
| Indonesian side | 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 and gas synthesis |
| PRODUCTS | Synthetic fuel oil, chemicals |
| SCOPE OF THE STUDY | 1) Market survey on alternative liquid fuel and basic chemicals in Indonesia<br>2) Survey on reserves, quality and mining cost of Banko coal<br>3) Survey on gasification characteristics of Banko coal, using a small scale test plant<br>4) Investigation of a master plan for effective utilization of Banko coal<br>5) Financial analysis and economic evaluation for proposed project |
| DURATION | 1984 – 88 (5 years)<br>1) Strategic investigation stage : One year<br>2) Coal gasification test stage : 2.5 years<br>3) Feasibility study stage : 1.5 years |

Fig. 4-1 Flow Chart of Implementation Plan



# 3. PROGRESS MADE IN THE 2ND STAGE

1. Sampling of Banko coals and its gasification test
2. As schedule without any trouble

1) FY 1985

i) Detailed design of the test facilities

ii) Survey on coal quality by shallow boring

iii) Preliminary evaluation of economic feasibility

2) FY 1986

i) Fabrication and construction of the test facilities

ii) Coal sampling work in N.W. Banko by deep boring

iii) Survey on market of fuel alcohol in Indonesia

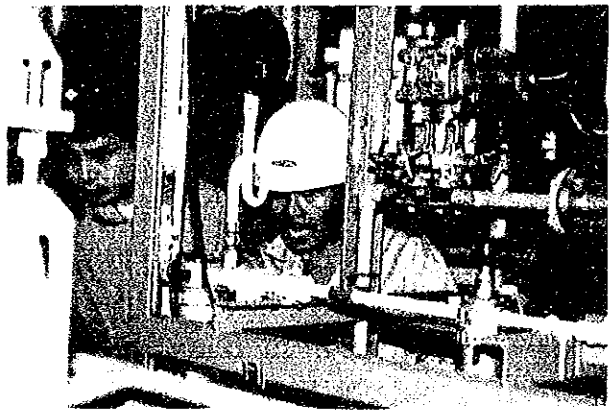
3) FY 1987

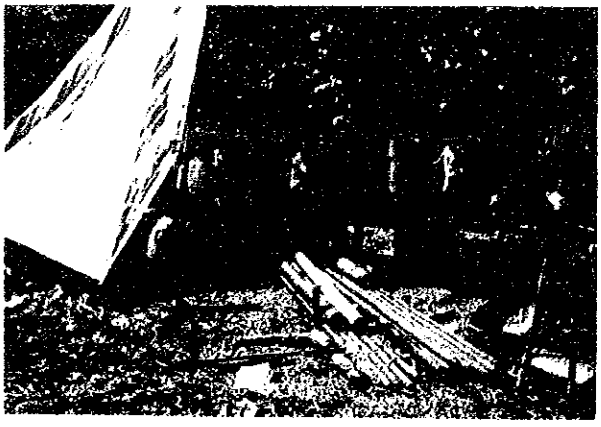
i) Coal sampling work in Central Banko and North Suban Jeriji by deep boring

ii) Coal gasification test and data analysis

iii) Overall evaluation for coal utilization technology

iv) Secondary economic evaluation for the master plan





# 4. RESULTS OF SURVEY ON COAL RESOURCES

1. Coal reserves is abundant, more than 435 million tons
2. Mining cost is 14.5 $/t as mined

1) Contributions by the Counterpart

i) Topographical maps and geological maps of Banko area

ii) Boring data in Banko area

iii) F/S report of N.W. Banko coal mining

2) Coal resources

i) Coal reserves (up to 100 meter depth)

| | | |
|---|---|---|
| N.W. Banko | : | 130 million tons |
| Central Banko | : | 130 |
| N. Suban Jeriji | : | 240 |

ii) Coal quality

Low grade coal containing high sodium in ash

| | T. moisture*1 (%) | Calorific value*1 (kcal/kg) | C | H (%) | O*2 |
|---|---|---|---|---|---|
| N.W. Banko | 27.6 | 4,650 | 74.4 | 5.8 | 17.9 |
| Central Banko | 36.7 | 3,800 | 71.7 | 6.6 | 19.9 |
| N. Suban Jeriji | 42.5 | 3,150 | 69.9 | 5.7 | 23.1 |

*1 as mined

*2 dry-ash-free base

3) Coal samples for coal gasification test

20 kinds, 200 kg per each sample

4) Spontaneous combustion test

105°C within 24 hours after start of storage by 5 m × 5 m × 2 m high

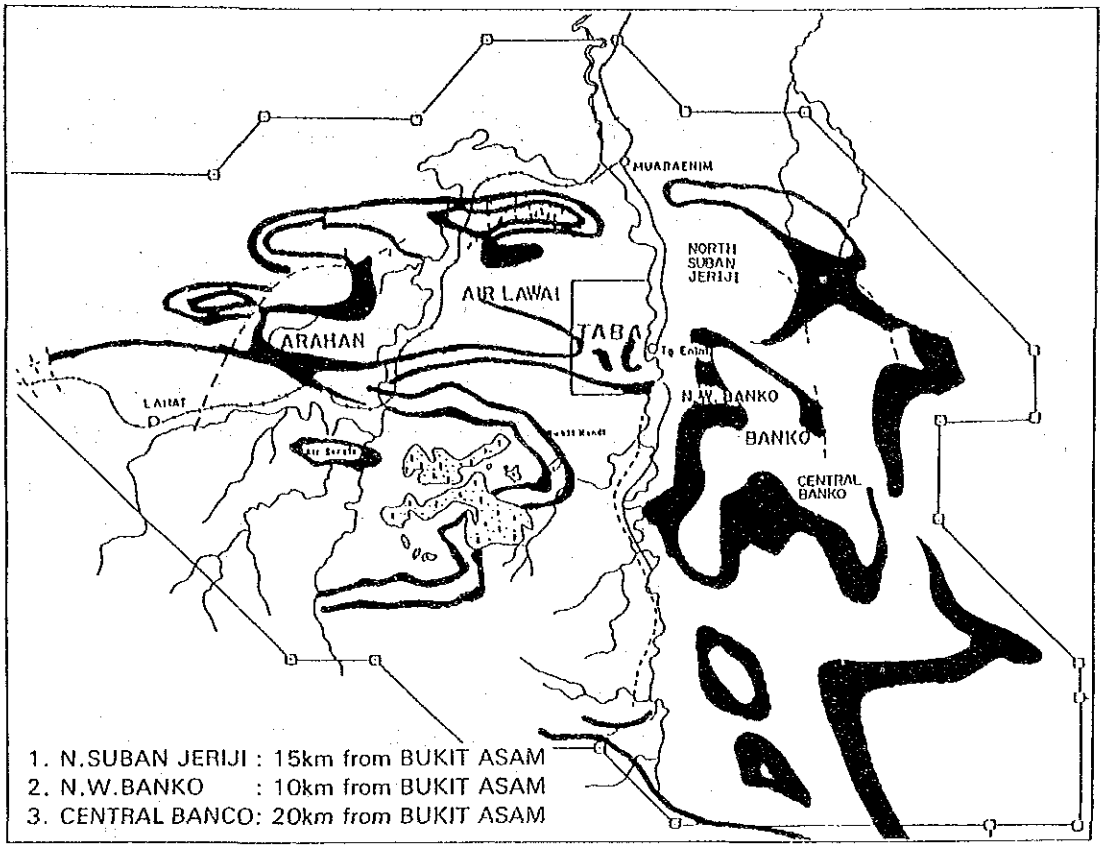



Fig. 2-3 Coal Resources in Western Part of South Sumatora Area

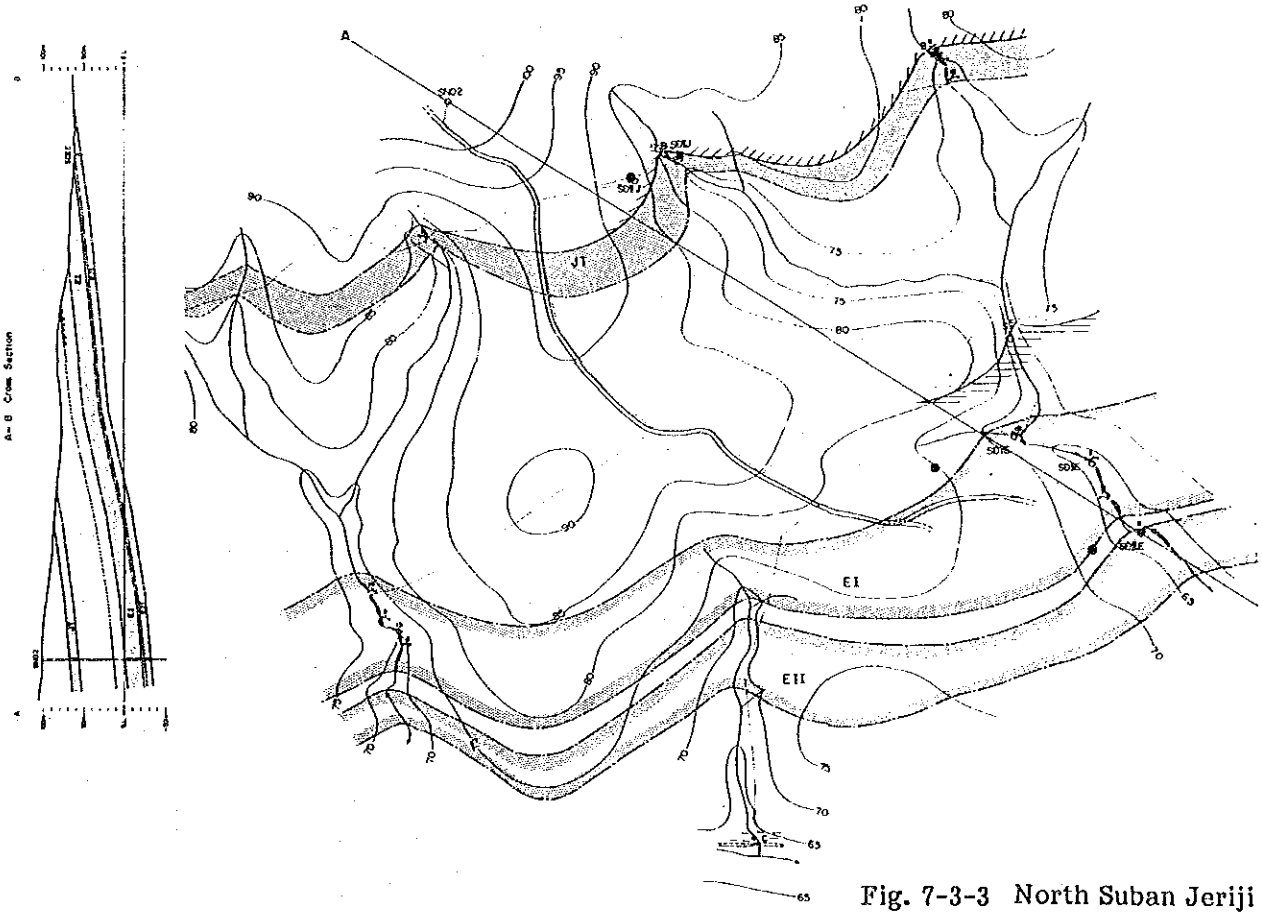



Fig. 7-3-3 North Suban Jeriji

# 5. RESULTS OF BANKO COAL GASIFICATION TEST

1. Banko coal gasification by a molten iron bath process has been technologically proven
2. Technology transfer has been pursued through the coal gasification test

1) Coal gasification test facilities

Process : Molten iron bath
Capacity : 30 kg/h of coal
Place : Laboratory for Energy and Energy Resources of PUSPIPTEK, Jakarta

2) Coal gasification test

Schedule : July – Dec. 1987
Coal samples tested : 20 kinds
Test method : Twice per each sample coal
30 minutes per one test run

3) Gasification characteristics of Banko coal

All coals can be gasified without any technical difficulty.

| Coal basin | CO | $H_2$ (%) | $CO_2$ | Gas volume ($Nm^3$/t coal as mined) |
|---|---|---|---|---|
| N.W. Banko | 59.0 | 28.1 | 3.9 | 1530 |
| Central Banko | 55.2 | 29.6 | 4.3 | 1310 |
| N. Suban Jeriji | 57.5 | 27.8 | 4.5 | 1130 |

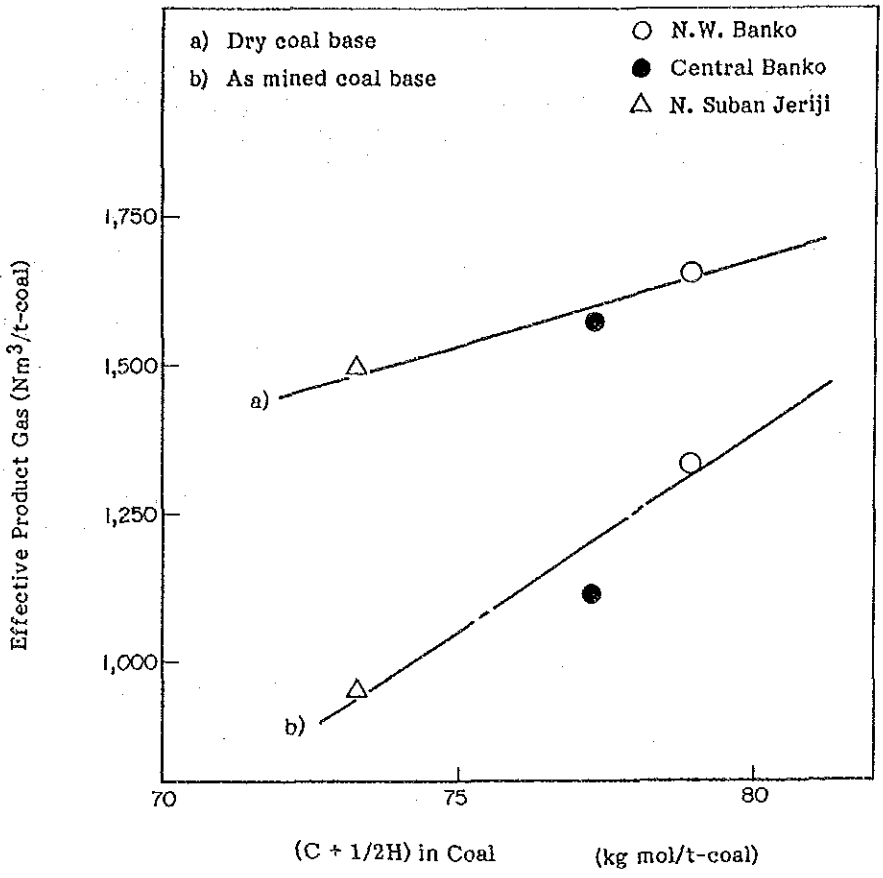



Fig. 11-2-1 Effect of Coal Quality on Effective Product Gas Volume

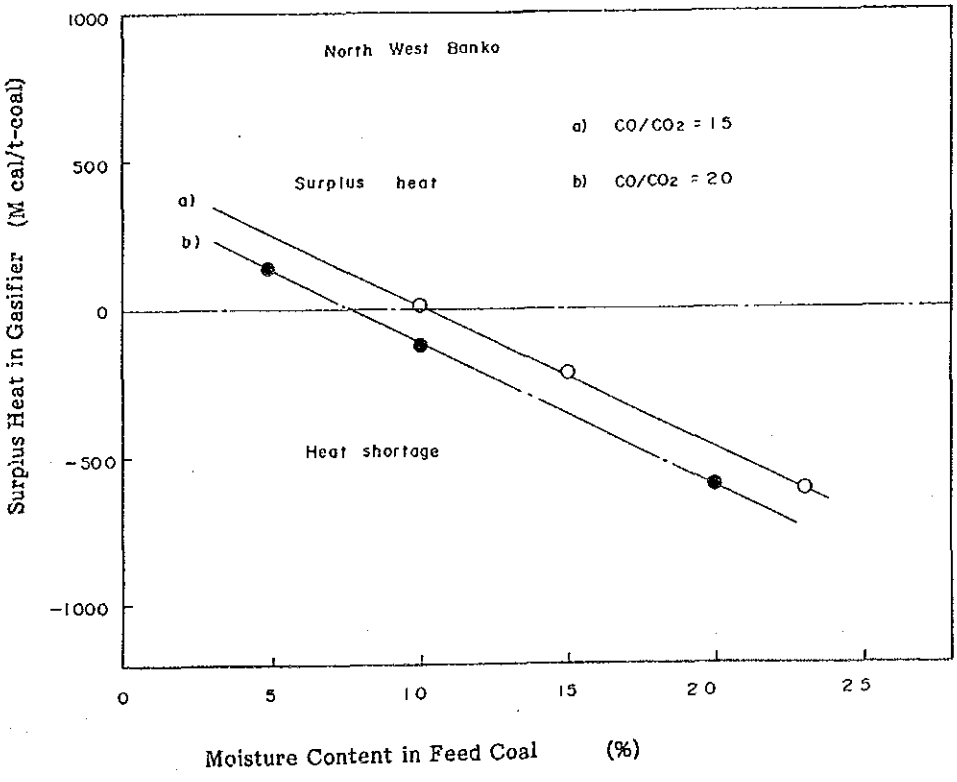



Fig. 8-4-8 Effect of Moisture Content in the Feed Coal on the Heat Balance

# 6. RESULTS OF SURVEY ON BANKO COAL UTILIZATION TECHNOLOGY

All of the necessary technology for Banko coal utilization through gasification have been developed at commercial scale

1) Technology for coal gasification

Molten iron bath process : 240 t/d prototype test stage

2) Technology for derivatives

| | | | |
|---|---|---|---|
| Methanol | : | Conventional, commercialized | |
| Urea | : | Conventional, commercialized | |
| Electricity | FBCB | : | Prototype test stage |
| | CGCC | : | Prototype test stage |

Note: Conventional boiler is not preferable because of high sodium content in ash

3) Technology for methanol utilization

| | | |
|---|---|---|
| Chemical | : | Conventional, commercialized |
| Engines | : | Fleet test stage |
| Fuel cell | : | Development stage |
| Special chemicals | : | Development stage |

4) Specification of fuel methanol

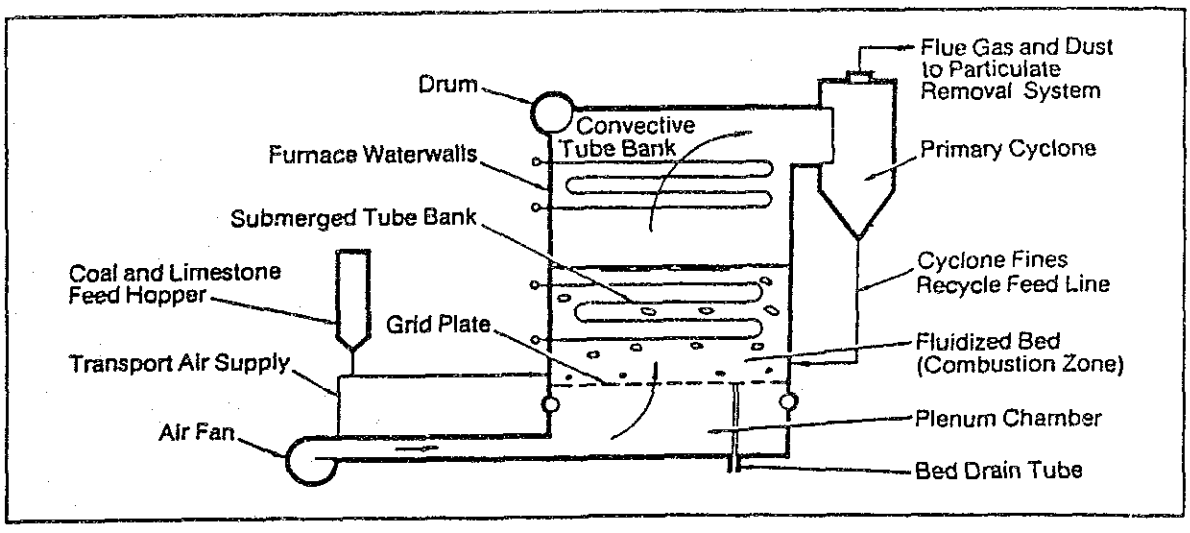
Not specified through the world, but no problem for any specification required.

Table 9-1-8 Evaluation of Coal Gasification Technology for Synthesis Gas Production

| | Fixed bed (dry ash) | Fludizied bed | Entrained flow | Molten iron bath |
|---|---|---|---|---|
| Availability for Banko coal | 10 | 1 | 10 | 1 |
| Gas composition | 5 | 5 | 2 | 1 |
| Impurity | 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 |
| Commerical experience | 1 | 1 | 1 | 2 |
| Total | 28 | 16 | 24 | 11 |
| Overall evaluation (ranking) | 4 | 2 | 3 | 1 |

Note: Lower number is better in performance.

Fig. 9-3-2 Scheme of Bubbling Fluidized Bed Boiler



# 7. RESULTS OF SURVEY ON MARKETS

Potential demand of fuel methanol for internal combustion engines is expected

1) Background

Export of oil is the most important role in Indonesia providing both foreign exchange and government revenue.
However, growing domestic consumption began to divert oil from export into domestic market.
Development of alternative energy from indigenous natural resources is urgent program in Indonesia.

2) Domestic price of petroleums

Domestic retail prices of petroleums were increased in 1982, 1983, 1984 and 1985 to eliminate the domestic subsidy for petroleums.
However the price level is still 30 – 50 % of Japan.

3) Demand for fuel methanol

Fuel methanol demand, according to LP model study, can not be expected even at 30 $/bbl of crude oil price if domestic petroleum prices are not increased.

4) Potential demand for fuel methanol

| | Penetration stage | Ultimate stage |
|---|---|---|
| Potential demand | 50 ~ 80 × $10^3$ kl/y | 8150 × $10^3$ kl/y |
| Fields of demand | Gasoline blend | Gasoline blend<br>Diesel oil substitution<br>Gasoline substitution |

5) Export of fuel methanol

Economically feasible if oil price is higher than 30 $/bbl

Fig. 10-1-1 Hydrocarbon Exports/Total Exports (In Percent)

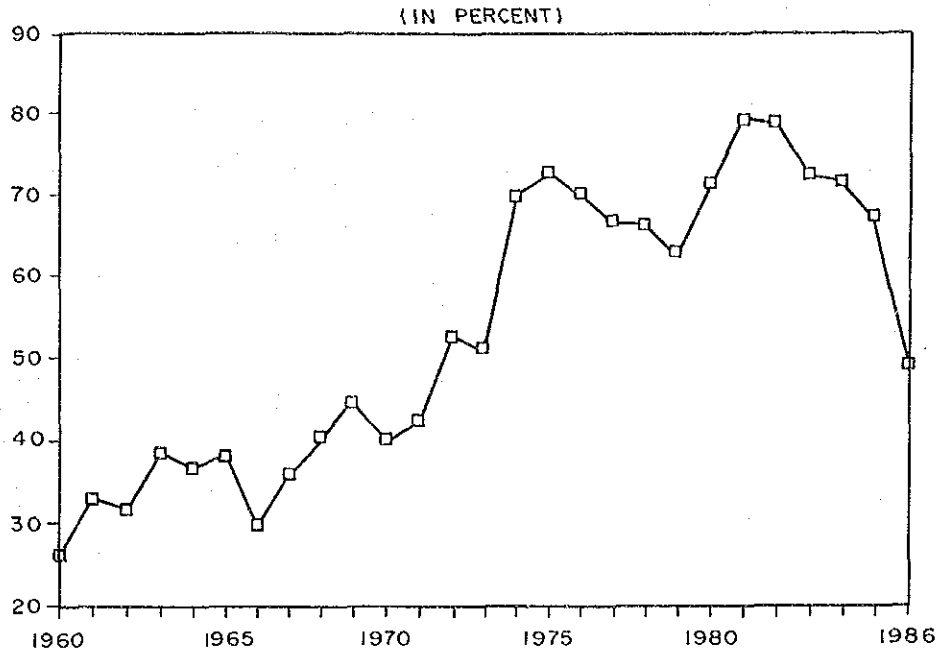
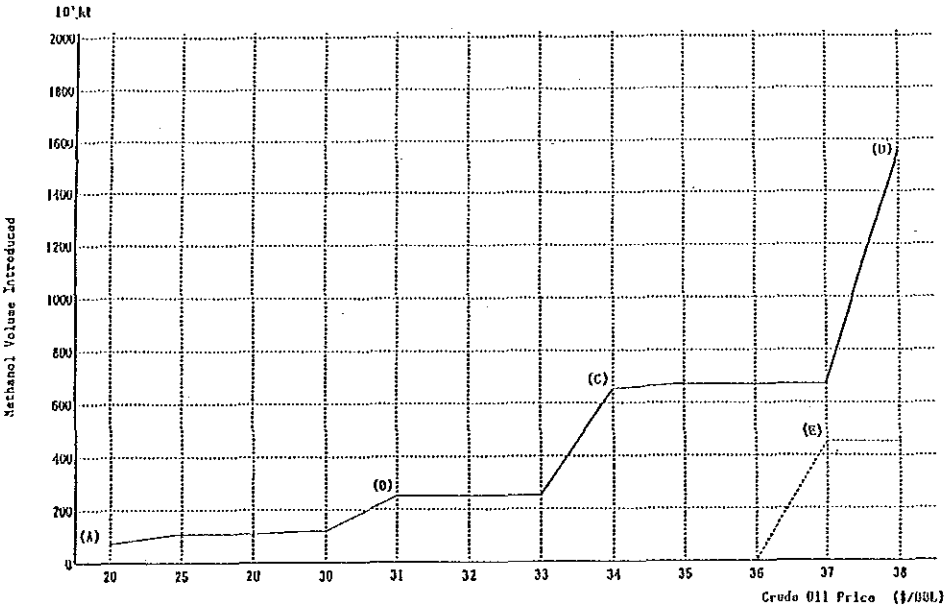



Fig. 10-3-3 Methanol Volume Introduced (v.s. Crude Oil Price)




Assumptions: Methanol Price 139$/kl

Economic benefits obtained by introducing fuel methanol into Indonesia was determined only by the difference between the cost for introduction of fuel methanol (IRR = 13.5%) and increase in profits obtainable from the increase in the export of oil and oil products. Problems by the decrease of oil export are not considered in this LP model.

# 8. INTEGRATION STUDY AND REVIEW OF MASTER PLAN

1. N.W. Banko is the most economical coal basin
2. Material balance for a master plan was established
3. Mine mouth plants are technically feasible

1) Evaluation of coal basins

| | | N.W. Banko | Central Banko | North Suban Jeriji |
|---|---|---|---|---|
| Coal cost | (%) | 20.0 | 24.0 | 27.7 |
| $O_2$ cost | | 28.0 | 27.6 | 26.7 |
| Scrap cost | | 1.5 | 1.5 | 1.6 |
| Lime cost | | 0.5 | 2.3 | 1.7 |
| Fixed capital cost<br>Labor cost<br>Utility cost<br>Interest etc. | | 50.0 | 52.4 | 55.0 |
| Total production cost | (%) | 100.0 | 107.8 | 112.7 |
| Rank | | 1 | 2 | 3 |

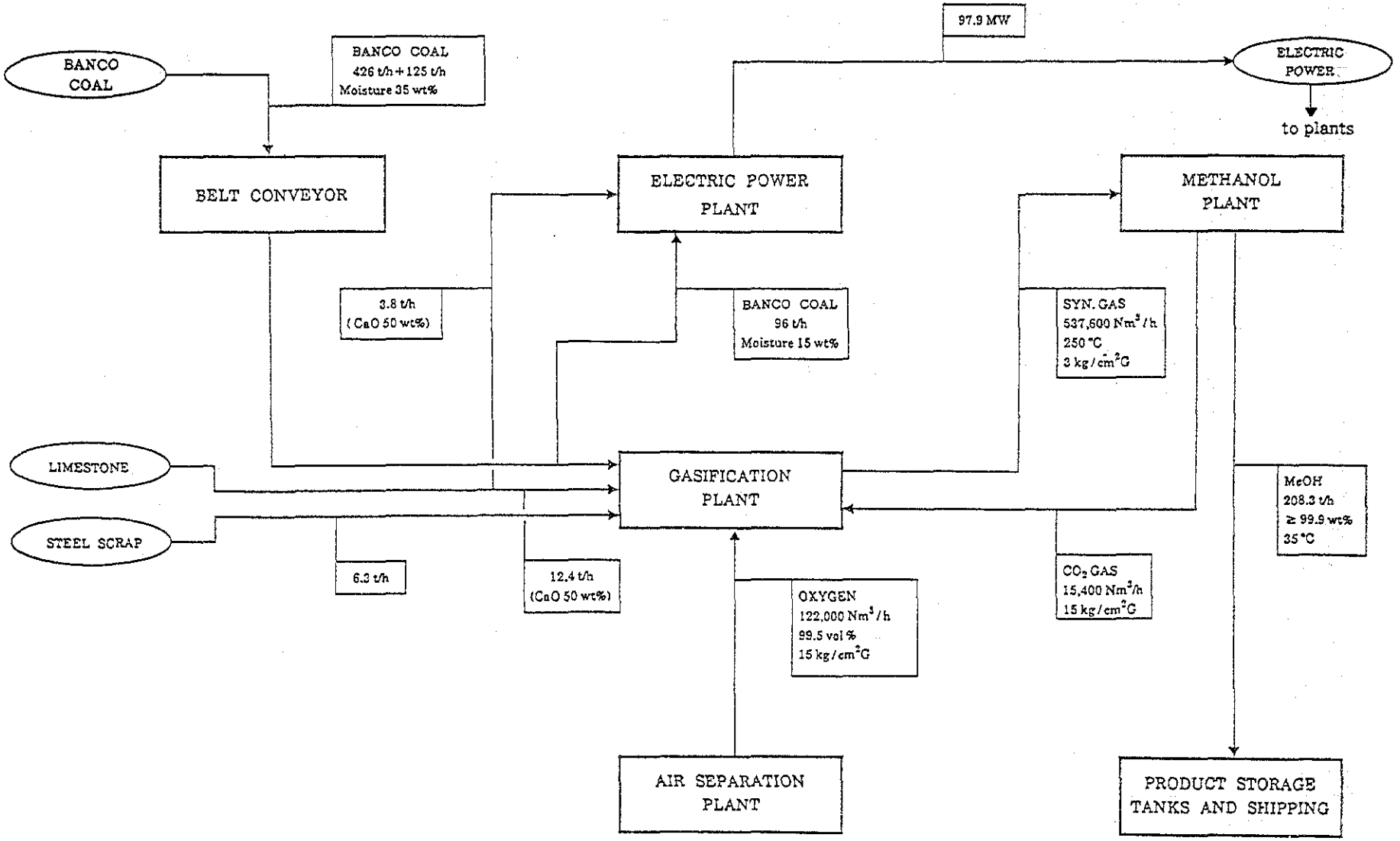
2) Review of master plan

| | | Base case | Alternative case |
|---|---|---|---|
| Coal feed rate | $10^3$ t/y | 4,200 | 4,500 |
| Methanol production | $10^3$ t/y | 1,600 | 1,300 |
| Urea production | $10^3$ t/y | - | 560 |
| Electricity generation | MW | 100 | 150 |
| Sales of electricity in Java | | 0 | 0 |

Note i) Fluidized bed boiler for electricity power generation was selected by comparison of economics between FBCB and CGCC.

ii) Sales of electricity in Java was abandoned because of less economic feasibility

Fig. 12-3-22 Overall Material Balance (Case 1)



# 9. PRELIMINARY CONCEPTUAL DESIGN OF THE PLANTS

1. There is no objection for mine mouth project
2. Capital investment is appr. 1,100 billion Rupiah*

1) Preliminary conceptual design

| | | |
|---|---|---|
| Plant location | : | Tanjung Enim near Banko |
| Traffic for transportation | : | Palembang port and Enim Riv. |
| Plant space | : | 400,000 $m^2$ |
| Process | | |
| Coal gasification | : | Molten iron bath process |
| Electricity generation | : | Fluidized bed combustion boiler system |
| Others | : | Conventional process |

2) Basic data for financial analysis

| | | Base case | Alternative case |
|---|---|---|---|
| Capital investment costs | (billion R) | 1,100 | 1,250 |
| Fixed capital investment | | (1,000) | (1,180) |
| Working capital | | (50) | (60) |
| Start up expense | | (9) | (10) |
| Annual expense | (billion R/y) | 230 | 270 |
| Fixed cost | | (140) | (170) |
| Variable cost | | (90) | (100) |

Note : Coal mining is out of the project.
Therefore mining cost of 14.5 $/t as mined is included in variable cost.

* Assumed exchange rates in the 2nd stage of the study are as follows.

1 Rp = 0.18 ¥
1 US$ = 200 ¥

| % | Million Rupiah | % | Project outline |
|---|---|---|---|
| | Coal mining<br>125,000 | 11.2 | 4.2 million tons/y (as mined)<br>Shovel and truck system |
| 4.4 | Coal transportation<br>43,800 | 3.9 | Belt conveyor = 15 km, 2 trains |
| 30.4 | Coal gasification<br>301,900 | 27.0 | Molten iron bath process<br>3.3 million tons/y · coal (as mined)<br>Gasifier = 5.4mϕ×18 mL×4 units |
| 20.0 | Methanol<br>188,400 | 16.8 | Lower pressure process<br>2,500 tons/h · methanol/train<br>2 trains |
| 9.0 | Air separation<br>89,200 | 8.0 | Cryogenic cold box system<br>300,000 $Nm^3/h$ · air × 2 trains |
| 10.0 | Power plant<br>99,700 | 8.9 | Fluidized bed boiler system<br>190 tons/h · steam × 4 units |
| 16.1 | Support facilities<br>159,600 | 14.3 | Storage = 50,000 kl × 2 tanks<br>Utilities = cooling water, air etc.<br>Administration = office, work shop etc. |
| 6.4 | Equipment transportation<br>63,700 | 5.7 | Tug boat = 1,500 HP<br>Barge = 3,000 DWT |
| 4.8 | Contingency<br>47,600 | 4.3 | |
| | Total | | |
| 993,900 | | 1,119,000 | |

# 10. PRELIMINARY FINANCIAL ANALYSIS AS OF THE 2ND STAGE

1. Base case shows slightly better economics than alternative case
2. If oil price is higher than 30 $/bbl, fuel methanol from Banko coal is economically feasible

1) Assumption for financial analysis

The following assumptions were assessed only for the purpose of preliminary financial analysis.

| | | |
|---|---|---|
| Equity/loan | : | 25 : 75 |
| Project life | : | 30 years |
| Escalation | : | None |
| Interest | : | 8 %/y |

2) Results of financial analysis

i) Base case shows slightly better economics than Alternative case.

ii) 13% of IRR of Base case is evaluated as "feasible" because of an energy project.

3) Profitability of fuel methanol (in Japan)

| | | |
|---|---|---|
| Oil price $\leqq$ 25 $/bbl | : | No profit |
| $=$ 30 | : | Critical but hopeful |
| $\geqq$ 35 | : | Superior |

Note: Evaluation method and desired criteria

$$IRR \geqq 11\%;\ \sum_{i=0}^{n} \frac{(C\,in,\,i - Cout,\,i)}{(1+\Gamma)^{i}} = 0$$

where Cin, i = Cash-in flow at i th year
Cout, i = Cash-out flow at i th year
$\Gamma$ = Discount rate ( $\Gamma$ = IRR )
n = Project life

Fig. 13-3-1 Sensitivity of Cost-effective Factors for Case 1

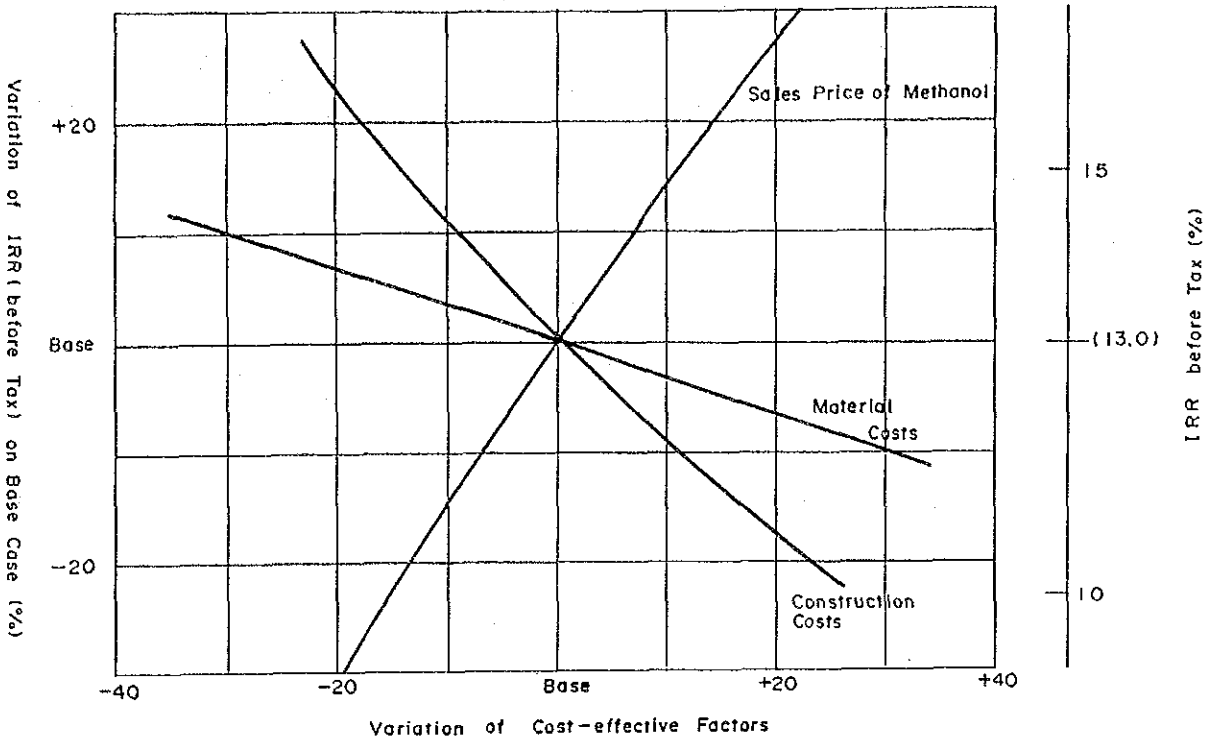



Fig. Shifts in Price of Crude Oil (FOB OPEC), Methanol and Urea (CIF Japan), and Electricity Rate in Indonesia and Japan