ECONOMICS OF BROWN COAL LIQUEFACTION PROCESS FOR BANKO COAL

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Abstract
Tulisan ini mengenai ringkasan analisis keekonomian pabrik komersial pinoir pencairan batubara Banko yang dibangun di Sumatera Selatan. Pabrik komersial tersebut diasumsikan mempunyai kapasitas of 6,000 t/d, 12,000t/d and 30,000t/d coal (daf). Sejak batubara Banko ditemukan mahal jika diangkut jarak jauh karena kadar airnya dan sifat pembakaran spontan, lokasi pabrik darus ditempatan di mulut tambang Banko Selatan (Tanjung Agung). Proses gasifikasi entrained HYCOAL menggunakan batubara Banko diadopsi untuk pemabngkit hydrogen. Produk minyak diangkut dengan dikapalkanmelalui rute pemipaan ganda Tanjung Agung/Plaju (approx. 202 km) dan Tanjung Agung/Tanjung Api-Api (sekitar. 265 km). Total batubara Banko yang dibutuhkan pabrik 12,000 t/hari termasuk untuk gasifikasi dan boiler 39,500 ton/hari. Harga batubara diset dalam 3 kategori yaitu US$11, US$12, and USD$13 per ton. Biaya konstruksi untuk pabrik komersial 6.000, 12.000 and 30.000 ton/hari adalah berturut-turut US$1.429juta, US$2.521juta, and US$5.385juta (1US$=120yen= Rp.9,500). . Analisa ekonomi berdasarkan metode DCF terhadap pabrik komersial 12,000 ton per hari menghasilkan produk minyak setara minyak mentah senilai US$ 22.5/bbl (FOB Plaju) and US$ 22.6/bbl (FOB Tanjung Api-Api) pada tahun 2011, saat pabrik mulai beroperasi.

Keywords: *batubara Banko, HYCOAL, pencairan batubara*

1. INTRODUCTION

Because of resource limitation of conventional petroleum caused by rapid rate of economic growth particularly in the Asian countries, there will be a worldwide shortfall in petroleum fuels in near future. This shortfall will impact the countries by constraining their ability to maintain their share of imports, and as a result, world is likely to experience a liquid fuels shortfall anytime between 2005 and 2030. Producing high quality fuels from coal is one option to alleviate this shortfall. If the coal conversion is to play a significant role in alleviating the liquid fuel supply problem, then the liquefaction technologies must be in the state of readiness for commercial deployment. Because lead times for the introduction of new energy technologies are on the order of 10 years after technologies are technically ready for commercial deployment, the countries must come to grips with this problem in no time.

The direct coal liquefaction technology has undergone very significant improvements over the past decade by continuing R&D and achieved a high level of technical readiness. Therefore, it is a good opportunity to evaluate the advanced technology applied in this country having huge amount of low-rank coal undeveloped. BPPT and Kobe Steel Ltd.(KSL) have conducted the feasibility study for the production of clean transportation fuels from Banko coal in the South Sumatra region. The major objectives of this study are to first perform conceptual design of demonstration scale plant, and then to identify the potential feasibility of direct coal liquefaction project at a pioneer commercial plant in this country. This paper presents the summary of economical analysis of the pioneer plant.

2. CONCEPT OF COMMERCIAL PLANT

On the basis of the technical information acquired in the demonstration plant investigations, as well as the Indonesian situation, a concept of a commercial plant is summarized in Table 1.

2-1. Plant Scale

The commercial plant was assumed to have capacity of 6,000 t/d, 12,000t/d and 30,000t/d on moisture and ash free coal basis with one train capacity of 6,000 t/d.

Table 1 Major Concept of Liquefaction Plant

Plant Site	Tanjung Agung, South Sumatra
Plant Scale	6,000t/d 12,000t/d 30,000t/d dafc basis
Feed Coal	Banko Coal (moisture 35.8%wb, ash 9.0%db)
Product	Synthetic Transportation Fuels, LPG, Chemicals
Production of Fuels	26,700bbl/d 53,400bbl/d 133,400bbl/d
Process Applied	Improved BCL Process
Hydrogen Source	Coal Gasification by HYCOL Process
Shipping Terminal	Plaju, Tanjung Api-Api

2-2. Plant Location

Since Banko coal has a difficulty to be transported for long distance economically because of its high moisture content and spontaneous combustion characteristic, the plant location was naturally sited near the mine mouth of Central Banko (Tanjung Agung), although coastal location may be a possible alternative.

2-3. Hydrogen Source

There are the two sources for production of hydrogen gas, which is essential for the coal liquefaction. In this study, the entrained coal gasification (HYCOL) process using raw Banko coal was adopted for hydrogen generation in view of possible shortage of natural gas in this region, which is an alternative source to generate hydrogen via steam reforming.

2-4. Shipping Terminal

Assuming that the liquefaction plant would be located adjacent to the coal mine mouth, the product oil must be transported to the existing crude petroleum oil refineries for further treatment. This study assumed to transport the product oil from the liquefaction plant in Tanjung Agung to Plaju or Tanjung Api-Api where the shipping terminal would be available.

2-5. Feed Stocks and Products

Feed stocks required and products from the conceptual commercial plant are shown in Table 2. In the case of 12,000t/d plant, this plant would produce crude liquefied oil at 53,400 barrels every day from raw Banko coal of 39,500 tons which includes coal for gasification and boiler sections.

Table 2 Feed Stocks and Products

Plant Scale	Banko Coal Required (t/d raw coal)	Oil Production (bbl/d)
6,000t/d	19,200	26,700
12,000t/d	39,500	53,400
30,000t/d	98,900	133,400

3. PROCEDURE OF ECONOMIC ANALYSIS AND LIQUEFIED OIL PRICE ESTIMATES

Based on the technical results obtained in this study, estimates were made as to the selling prices of product oils and the timing of when the commercial plant could be realized economically.

The Discount Cash Flow Rate of Return (DCF) method was adopted, that is popular in many enterprises in the world for economic evaluation of projects. The net cash flow of each year from the year of construction commencement to the last year of operation is converted to an equivalent in the first year of operation by using a discount rate (rate of return on investment). The oil selling price required in the first year of operation is determined on the assumption of fixed Return On Equity (ROE) so that the total of the discounted annual cash flow is zero.

4. MAIN CONDITIONS AND ASSUMPTIONS FOR ECONOMIC ANALYSIS

Economic analysis to estimate the Crude Oil Equivalent Price (COEP) US dollars per barrel was carried out with the following major assumptions.

4-1. Construction Cost

To obtain the construction cost estimates, the exponential method is generally applied. Scale-up factors were set for each section by considering its specification and characteristics. The overall construction costs of 6,000t/d, 12,000t/d and 30,000 t/d conceptual commercial plant in Indonesia are presented in Table 3.

Table 3 Construction Costs of 30,000 t/d Commercial Plant

Plant Scale		Construction Cost
Cost for 6,000 t/d single train	MMUS$	1,429
Cost for 12,000 t/d double train	MMUS$	2,521
Cost for 30,000t/d full scale plant	MMUS$	5,385

Notes The above construction costs include coal gasification plants to generate hydrogen gas, exclude pipeline and terminal for product transportation and shipping.

4-2. Exchange Rate
Currency exchange rates were assumed for 1US$=120¥=9,500Rp, which are annual average of year 2001.

4-3. Land Price
According to PTBA estimate, the expected land price is 1.5US$/$m^2$. The price includes land fee and cost for land cleaning and leveling.

4-4. Plant Staffs and Unit Labor Cost
Personnel requirement for the commercial plant was estimated at the total 520 staffs (6,000t/d), 900 staffs (12,000t/d) and 1,880 staffs (30,000t/d) respectively according to the experience of the pilot plant operation in Australia. Their mean annual labor cost was also estimated at 9,800$/man.year by the information of Indonesian side.

4-5. Related Taxation
Related taxation was referred to Indonesian side information as shown in Table 4.

Table 4 Related Taxation

Tax	Indonesia
Municipal Property Tax	0.1%
Corporate Tax	30%

Notes: The preferential treatment of the tax is not considered.

4-6. Coal Prices for Feed Stock
PTBA recommended three different prices in accordance with the amount of raw coal supply as shown in Table 5. The coal price varies from 11 $/t-raw coal (17.2 $/t-dry coal) to 13 $/t-raw coal (19.9 $/t-dry coal) at the battery limit of the liquefaction plant.

Table 5 Coal Prices for Feed Stock

Plant Scale	Annual Demand	Coal Prices
6,000 t/d-dafc	5.94 MMtons	13$/t-ROM
12,000 t/d-dafc	12.26 MMtons	12$/t-ROM
30,000 t/d-dafc	29.72 MMtons	11$/t-ROM

4-7. Electric Power
In the last Applicability Study, the unit price of electricity from PLN was set at 0.05$/kWh, because 10% of the total electricity demand was planned to purchase from PLN. Although there is a small (260MW) power plant near the plant site, it could not be expected to use in the liquefaction plant due to the short supply and quality problems. The main equipment such as hydrogen compressors and slurry boosting pumps in the liquefaction plant require high standard of power with no power dip and no frequency fluctuation. Therefore, whole power requirement shall be covered by the power plants of its own.

4-8. Transportation Cost
The product oils must be transported and shipped for deliver. Two pipeline routes i.e., Tanjung Agung/Pladju (approx. 202 km) and Tanjung Agung/Tanjung Api-Api (approx. 265 km) were studied. The existing port terminal is the port at Plaju/Sungai Gerong. This port is currently owned and operated by PERTAMINA for shipping oil products from its refineries. The South Sumatra provincial government is conducting a feasibility study for construction of a new seaport at Tanjung Api-Api, which is near the Musi River. This seaport is an anticipation of concern on the increasing cost for maintaining the Musi river way. After commissioning the new seaport, larger vessels can be accommodated.

The transportation and shipping costs were predicted as shown in Table 6 using the DCF method. The cost for transportation and shipping between the liquefaction plant and the terminal should be added to the product oil price. On the other hand, delivery cost from the terminal to the existing large refineries was excluded. Consequently, the selling prices of liquefied oils are FOB prices at the shipping terminal.

Table 6 Transportation and Shipping Costs (12,000t/d case)

Shipping Terminal		Plaju	Api-Api
Shipping Oils bbl/d		53,400	
Construction Cost			
Pipeline	MM$	50.7	65.2
Terminal	MM$	74.1	
Utility	¢/bbl	11.7	16.3
Operators	man	24	30
Trans. & Shiping Cost (2002)	$/bbl	0.88	1.01

4-9. Crude Oil Equivalent Factor
The liquefied product oil prices are calculated by DCF method using assumptions, and then the prices equivalent to petroleum crude oil values are calculated in order to compare with petroleum crude oil prices, because the liquefied product oil is defined as “Ultra Light Clean Oil”. The liquefied oil is shipped after “In-line Hydrotreating” followed by the “Upgrading within the liquefaction process. The factor of 1.3 is obtained by dividing the product value of liquefied oils by the value of petroleum crude oil. This is regarded as the price conversion factor usable to express the product value as an equivalent crude oil price.

4-10. Summary of Economic Assumptions

Summary of assumptions for economic analysis is shown in Table 7. In order to carry out the price estimate in US$, all prices in 2002 were converted to US$ and then calculation have been made using interest rates, inflation rates, etc. applicable to the USA.

Table 7 Summary of Main Conditions and Assumptions for Economic Analysis

Raw Coal Price $/t	13(6,000t/d),12 (12,000t/d)11(30,000t/d)
Crude Oil Equivalent Factor	1.30
Construction Period	4 years (5 years in the case of DP)
Operating Period	25 years
Operation Factor	310days/year
Equity Ratio	25%
Maintenance Cost	3% per year on construction cost
Property Tax Rate	0.10% per year
Company Income Tax Rate	30% per year
Return on Equity (ROE)	10% per year
Bank Interest Rate Long Term	7.0% per year
Short Term	5.0% per year
General Inflation Rate	3.5% per year
Feed Coal Price Escalation	3.5% per year
Liquefied Oil Price Escalation	3.5% per year
Natural Gas Price Escalation	3.5% per year
Construction Cost Escalation	3.5% per year
Labor Wage Escalation	3.5% per year

5. RESULT OF ECONOMIC ANALYSIS

5-1. Estimated Selling Price at Shipping Terminal

The prices of the ultra-clean product oil, which would be sold from the years of operation commencement, were calculated. Table 8 shows the calculation results using the above conditions and assumptions (Base Case). The product oil could be sold competitively with crude petroleum oil, if the price calculated is same as or cheaper than the crude oil price at any time given. The results are expressed in terms of Crude Oil Equivalent (COE) for a 10% Return on Equity. For example, in the case where design and construction for a 12,000t/d pioneer plant will commence from 2007 based on the BCL process, and the products will be sold from 2011, the selling price at the shipping terminal could be 26.6 US$/bbl at a base of real value (excluding general inflation) condition.

Table 8. Product Oil Selling Prices at Shipping Terminals

Shipping Terminal		Plaju	Api-Api
Crude Oil Equivalent Price			
6,000t/d	US$/bbl	25.6	25.7
12,000t/d	US$/bbl	22.5	22.6
30,000t/d	US$/bbl	20.2	20.3

Notes
- Prices shown are actual value excluding general inflation.
- Construction starts in fiscal year of 2007, operation commencement in fiscal year of 2011.

5-2. Return on Equity under the Market Price Mechanism

Since the economy crisis occurred in the middle of year 1997 in this country, the subsidy for the domestic fuels has increased significantly. Such high subsidy forced the government to increase the domestic fuel prices gradually from 1998 until 2004 where the fuel prices will be no longer subsidized. In fact, the amount of subsidy is estimated to decrease to Rp 53.8 billion in 2001 and Rp 32.3 billion in 2002. If the domestic fuel prices will follow the international prices in the year 2004, each type of oil based fuel (OBF) will be priced around Rp 2,000 (March 2001 base) as shown in Table 9.

Table 9 Comparison of OBF Prices for Different Categories Based on Presidential decree No.45/2001 Issued on March 30, 2001

Unit : Rp./liter

Type of OBF	Mass Users	Industrial Users	**Market Prices***
Premium	1,150	1,150	**1,950**
Kerosene	350	1,080	**2,150**
Diesel Oil	600	990	**1,990**
Diesel Fuel	550	970	**1,940**
Fuel Oil	400	770	**1,540**

* It changes according to the international market price of oil.

The above market prices consist of the price of basic material plus processing, distribution, transportation and overhead costs at Pertamina. According to the estimation results carried out by Pertamina, such cost varied Rp 190-240 range when they projected the subsidy for each fraction of 2001's selling price based on Presidential Decree No. 135/2000. If the liquefied oils can be sold at the price which deducts the above costs from the market price, the actual selling price at the terminal(Tanjung Api-Api) would be Rp 1,690 per liter or 28.3$/bbl as shown in Table 10.

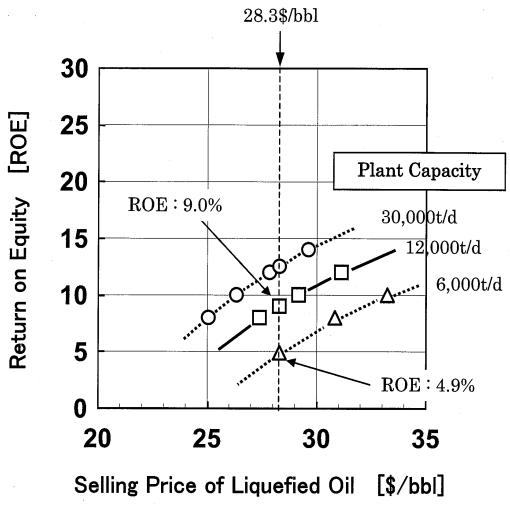
Table 10 Possible Selling Price of Liquefied Oil at Terminal

Unit : Rp./liter

Type of OBF	Market Prices[*1]	Cost[*2]	Material Price	Liquefied Oil Yield % dafc	Selling Price
Premium	1,950	240	1,710	LO 28.8	1,710
Kerosene	2,150	220	1,930	MO 22.0	1,855
Diesel Oil	1,990	210	1,780		
Diesel Fuel	1,940	206	1,734	HO 12.7	1,349
Fuel Oil	1,540	191	1,349		
Average	-	-	-	-	1,693

[*1] It changes according to the international market price of oil.
[*2] Processing, distribution, transportation and overhead costs total

Figure 1 compares the plant scale on the return on equity (ROE) under the standard economic condition mentioned in Table7 (only COE factor changed to 1.0 from 1.3). Although the selling price of the liquefied oil is subject to the international market, if the oil could be sold at 28.3$/bbl in 2011, ROE of the 12,000t/d case will be 9.0%. There is significant improvement (ROE 4.1%) from the case of 6,000t/d due to the "scale merit" on the liquefaction project. In the case of full-scale plant (30,000t/d), ROE will increase further to 12.5%.



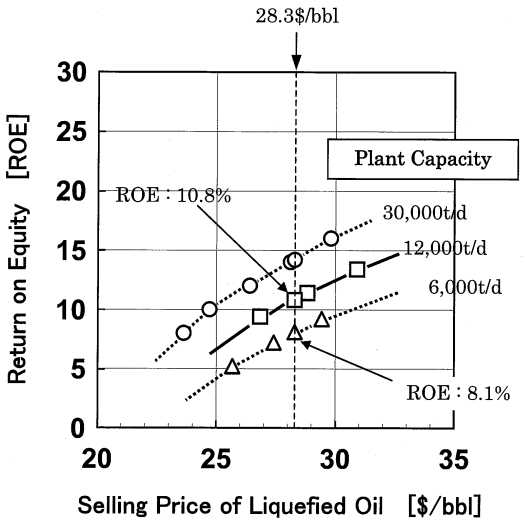
Coal Price :
30,000t/d 11$/tROM
12,000t/d 12$/tROM
6,000t/d 13$/tROM
Bank Interest Rate:7% (long term loan)
Corporate Tax : 30% and COE : 1.00

Figure 1 Effect of Plant Scale on Return on Equity (Base Case)

6. SENSITIVITY ANALYSIS

The economic sensitivity analysis was carried out to study the impact of changes in raw coal pricing and bank interest rate. Figure 2 shows the effect of raw coal prices on ROE. The raw coal will be mined and delivered by PTBA. For the 12,000t/d case, a change in raw coal price by 17% (12$/tROM →10$/tROM) changes the ROE by 1.8% (9.0%→10.8%). This change also improves the ROE for the 6,000t/d case by 3.2% (4.9%→8.1%).

Another analysis was executed for bank interest rate as shown in Figure 3. If the Japanese Environmental Yen Credit could be applied to this project by half of the total loan, the mean interest rate goes to 3.875%. From the figure, the decreasing bank interest rate by 3.125% (7%→3.875%) increases the ROE by 2.6%(9.0%→11.68%). This gives a significant impact on the feasibility of the liquefaction project. The third analysis is the effect of coal price and interest rate. Figure 4 shows that the decrease in both important conditions will bring the highest ROE, 11.3% (6,000t/d), 12.8% (12,000t/d) and 17.4% (30,000t/d) respectively.



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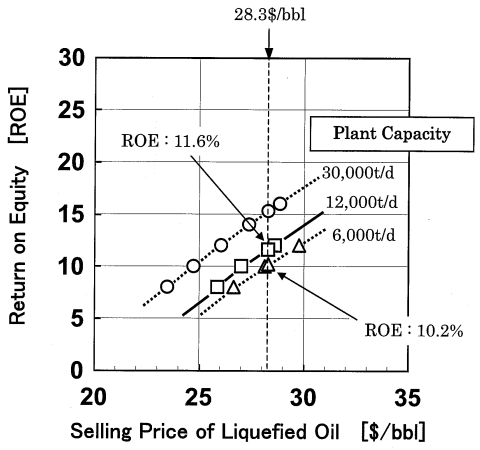
12,000t/d 12$/tROM
6,000t/d 13$/tROM
Bank Interest Rate : 7% (long term loan)
Corporate Tax : 30% and COE : 1.00

Figure 2 Effect of Coal Price on Return on Equity

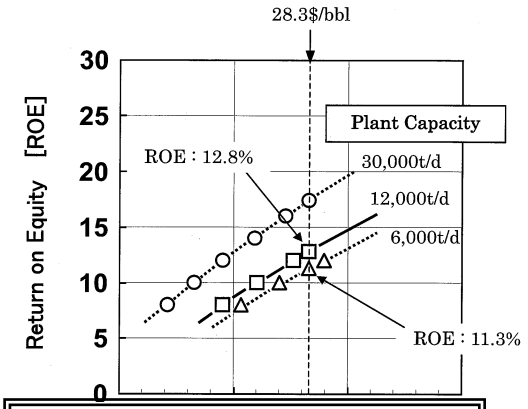
The governments can do much to encourage the establishment of a coal liquefaction industry

not only for the expenditure of treasury funds, but also taxation, acceleration of plant depreciation etc. Such incentives could lead the additional opportunity of employment and the revenue collections, particular in the South Sumatra region.



Coal Price :
30,000t/d 11$/tROM
12,000t/d 12$/tROM
6,000t/d 13$/tROM
Bank Interest Rate : 3.875% (long term loan)
Corporate Tax : 30% and COE : 1.00

Figure 3. Effect of Bank Interest Rate on Return on Equity



Coal Price :
30,000t/d 9.2$/tROM
12,000t/d 10$/tROM
6,000t/d 10.8$/tROM
Bank Interest Rate : 3.875% (long term loan)
Corporate Tax :30% and COE : 1.00

Figure 4. Effect of Coal Price and Bank Interest Rate on Return on Equity

7. CONCLUSION

Over the past decade continued research and development into the production of clean transportation fuels from low-rank coals in Indonesia has substantially increased both the quantity and quality of liquid products from a ton of coal.

Due to the superior characteristics of Banko coal for the liquefaction, the possibility of economic feasibility of a commercial liquefaction plant has been in progress by this study.

The economic analysis based on DCF method has brought about perspective that the proposed commercial plant which has 12,000t/d capacity could produce liquefied oil in the year of 2011, the year of commencement this commercial plant, at prices of:

FOB at Plaju	US$ 22.5/bbl crude oil Equivalent
FOB at Tanjung Api-Api	US$ 22.6/bbl crude oil Equivalent

The decrease in the feed coal price and the interest rate will bring the high ROE to the project, 11.3%(6,000t/d), 12.8%(12,000t/d) and 17.4% (30,000t/d) respectively. The governments can do much to encourage the establishment of a coal liquefaction industry not only for the expenditure of treasury funds, but also taxation, acceleration of plant depreciation etc. Such incentives could lead the additional opportunity of employment and the revenue collections, particular in the South Sumatra region.

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